U.S. DEPARTMENT OF COMMERCE
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
NATIONAL WEATHER SERVICE
NATIONAL METEOROLOGICAL CENTER

OFFICE NOTE 338

Skill of The Medium Range Forecast Group

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PURPOSE

This paper depicts in a graphical manner the skill of the Medium Range (3-10 day) Forecast Group (MRFG) man and machine (numerical model guidance) forecasts. It will be updated each February in order to present the latest scores for each of the several forecast categories in the MRFG. Only scores with at least a 5-year period of record are presented. This paper contains the standardized and unstandardized mean sea-level pressure and 500 mb correlation; the Gilman, Hughes and experimental precipitation skill; the minimum/maximum absolute temperature error; and the 5-day mean normalized 500 mb correlation, temperature, and precipitation skill scores.

Numerical Model Guidance (Past to Present)

1. Acronyms

   a. Baro - Reed Baratropic Advection Model Hemispheric
   b. 6L PE - 6-layer Primitive Equation Model Hemispheric
   c. CM - Course Mesh 380km FM - Fine Mesh 190km
   d. SMG26 - Spectral Model Global 24 modes 6-layers
   e. SMG2C - Spectral Model Hemispheric 24 modes 12-layers
   f. SMG3C - Spectral Model Global 30 modes 12-layers
   g. SMG4C - Spectral Model Global 40 modes 12-layers
   h. SMG4H - Spectral Model Global 40 modes 18-layers
   i. SMG8H - Spectral Model Global 80 modes 18-layers

2. 00Z Guidance

   a. To 84-hours

      (1) From 1970 through 1977: 6L PE CM
      (2) From 1978 through 1979: 7L PE FM
      (3) From January 1980 to August 15, 1980: 7L PE FM to 60-hours then 7L PE CM with Fourth Order Differencing to 84-hours.
      (4) From August 15, 1980 to April 15, 1981: SMG3C to 48-hours then SMH2C to 84-hours.
      (5) From April 15, 1981 through October 19, 1983: SMG3C to 48-hours then SMG2C to 84-hours.
      (6) From October 19, 1983 through December 1984: SMG4C
      (7) From January 01, 1985 through December 1986: SMG4H
      (8) From August 13, 1987 through December 1987: SMG8H

   b. Greater then 84-hours to 144-hours

      (1) From 1970 through 1979: Baro (Mesh 1977-1979)
      (2) From January 1980 to August 15, 1980: 7L PE CM with Fourth Order Differencing.
      (3) From August 15, 1980 to April 15, 1981: SMH2C
      (4) From April 15, 1981 through April 1982: SMG26
      (5) From May 1982 through October 19, 1983: SMG2C
      (6) From October 19, 1983 through December 1984: SMG4C
      (7) From January 01, 1985 through December 1986: SMG4H
      (8) From August 13, 1987 through December 1987: SMG8H

   c. Greater the 144-hours to 240-hours

      (1) From November 1977 through April 1981: Baro Mesh
      (2) From December 1977 through April 15, 1981: 3L PE CM
      (3) From April 15, 1981 through October 19, 1983: SMG26 to 192-hours then SMG26 to 240 hours.
      (4) From October 19, 1983 through December 1984: SMG4C to

240-hours.

(5) From January 01, 1985 through August 12, 1987: SMG4H to 240-hours.

(6) From August 13, 1987 through December 1987: SMG8H to 240-hours.

3. 12Z Guidance

a. To 60-hours

(1) From 1970 through 1977: 6L PE CM

b. Greater than 60-hours to 96-hours (500 mb only)

(1) From 1970 through 1977: Baro (mesh in 1977)

c. To 48-hours

(1) From October 1971 through August 1977: 7L PE FM (old LFM)
(2) From September 1977 through 1987: 7L PE LFM (127km)

d. Greater than 48-hours to 120-hours (500mb only)

(1) From 1978 through 1987: Baro run from the 48-hour LFM inserted into the 60-hour SMG8H from 00Z.

Forecast Day	Day 1	Day 2	Day 3	Day 4	Day 5
12Z	12Z	12Z	12Z	12Z	12Z
12hrs	36hrs	60hrs	84hrs	108hrs	132hrs

00Z 00Z 00Z 00Z 00Z 00Z 00Z

← SMG8H →

← 48hr LFM →← BARO →

Day 6	Day 7	Day 8	Day 9	Day 10
12Z	12Z	12Z	12Z	12Z
156hrs	180hrs	204hrs	228hrs	252hrs

00Z 00Z 00Z 00Z 00Z 00Z

SMG8H →

*Note OI analysis replaced the HUF in late July 1984.

Figures

Figure 1 depicts the North American (NA, 130 grid points) and the United States (US, 86 grid points) subset mean sea-level pressure (MSLP) and 500mb correlation score verification areas.

Figure 2 is a plot of the calendar year 1987 monthly mean standardized correlation scores for the man and NMC/NWP model North American area mean sea-level pressure progs verifying on days 3,4, and 5 after forecast day. (See Appendix A for an explanation of this score.)

Figure 3 is a plot of the 20/18 year (1968/70-1987) average monthly mean standardized correlation scores for the man and NMC/NWP model North American area mean sea-level pressure progs verifying on days 3,4, and 5 after forecast day. (See Appendix A for an explanation of this score.)

Figure 4 is a plot of the 1968/70 through 1987 calendar year standardized correlation scores for the man and NMC/NWP model North American area mean sea-level pressure progs verifying on days 3, 4, and 5 after forecast day. (See Appendix A for an explanation of this score.)

Figure 5 is similar to figure 2 except the score is unstandardized.

Figure 6 is similar to figure 3 except the average is for 11 years and the score is unstandardized.

Figure 7 is similar to figure 4 except the calendar years are 1977 through 1987 and the score is unstandardized.

Figure 8 is a plot of the calendar year 1987 monthly mean standardized correlation scores for the NMC/NWP model North American area 500-mb progs verifying on days 3, 4, and 5 after forecast day. (See Appendix A for an explanation of this score.)

Figure 9 is a plot of the 18 year (1970-1987) average monthly mean standardized correlation scores for the NMC/NWP model North American area 500mb progs verifying on days 3, 4, and 5 after forecast day. (See Appendix A for an explanation of this score.)

Figure 10 is a plot of the 1970 through 1987 calendar year standardized correlation scores for the NMC/NWP model North American area 500mb progs verifying on days 3, 4, and 5 after forecast day. (See Appendix A for an explanation of this score.)

Figure 11 is similar to figure 2 except the area is the United States.

Figure 12 is similar to figure 3 except the average is for 12 years and the area is the United States.

Figure 13 is similar to figure 4 except the calendar years are 1976 through 1987 and the area is the United States.

Figure 14 is similar to figure 5 except the area is the United States.

Figure 15 is similar to figure 6 except the area is the United States and the average is for 12 years.

Figure 16 is similar to figure 7 except the area is the United States and the calendar years are 1976 through 1987.

Figure 17 is similar to figure 8 except the area is the United States.

Figure 18 is similar to figure 9 except the average is for 11 years and the area is the United States.

Figure 19 is similar to figure 10 except the calendar years are 1975 through 1987 and the area is the United States.

Figure 20 is a plot of the calendar year 1987 monthly mean normalized correlation scores for the man, NMC/NWP model, European Center for Medium Range Weather Forecasting (ECMWF), and Linear Regression (LR - see NMC on 259 of June 82) North American area 500mb mean progs verifying 6 to 10 days after forecast day.

Figure 21 is a plot of the 9 year (1979-1987) average monthly mean normalized correlation scores for the man and NMC/NWP model North American area 500mb progs verifying 6 to 10 days after forecast day.

Figure 22 is a plot of the 1979 through 1987 calendar year normalized correlation scores for the man, NMC/NWP model and ECMWF (1982-1987) North American area 500mb mean progs verifying 6 to 10 days after forecast day.

Figure 23 depicts the 41 stations in the United States where the temperature forecasts are verified.

Figure 24 is a plot of the calendar year 1987 bi-monthly mean absolute error minimum temperature scores for the man, Klein Lewis (KL) objective, linear regression and climatology temerature forecasts verifying on days 3, 4, and 5 after forecast day.

Figure 25 is a plot of the 17 year (1971-1987) average bi-monthly mean absolute error minimum temperature scores for the man, KL, and climatology temperature forecasts verifying on days 3, 4, and 5 after forecast day.

Figure 26 is a plot of the 1971 through 1987 calendar year absolute error minimum temperature scores for the man, KL, and climatology temperature forecasts verifying on days 3, 4, and 5 after forecast day.

Figure 27 is similar to figure 24 except the temperature is maximum.

Figure 28 is similar to figure 25 except the temperature is maximum.

Figure 29 is similar to figure 26 except the temperature is maximum.

Figure 30 is a plot of the 1972 through 1987 calendar year absolute error (minimum + maximum) ÷ 2 temperature scores for the man, KL, and climatology temperature forecasts verifying on days (3+4+5) ÷ 3 after forecast day.

Figure 31 is a plot of the calendar year 1987 monthly mean 5-class temperature skill scores for the man, forecast persistence (FP - persistence of the 1-5 day mean temperature forecasts as a 6-10 day), linear regression (LR - see NMC on 259 of June 82), and observed (T OBS - persistence of the 5 day mean observed temperatures as a 6-10 day forecast) mean temperature forecasts verifying 6 to 10 days after forecast day. (See Appendix B for an explanation of this score.) after forecast day.

Figure 32 is a plot of the 10 year (1978-1987) average monthly mean 5-class temperature skill scored for the man, FP, LR, and T OBS mean temperature forecasts verifying 6 to 10 days after forecast day.

Figure 33 is a plot for the 1978 through 1987 calendar year 5 class temperature skill scores for the man, FP, LR, and T OBS mean temperature forecasts verifying 6 to 10 days after forecast day.

Figure 34 is similar to figure 31 expect the temperature skill scores are 3-class.

Figure 35 is similar to figure 32 except the temperature skill scores are 3-class.

Figure 36 is similar to figure 33 except the temperature skill scores are 3-class.

Figure 37 depicts the 100 stations in the United States where the precipitation forecasts are verified.

Figure 38 is an example of a day 3, 4, or 5 precipitation forecast. The dashed lines are the 24-hour departure from normal probability of precipitation (DN POP) forecast for January 3. The solid lines are the 24-hour climatological (normal) probability of precipitation (NPOP) for the first 15 days of January. A total of (DN POP + NPOP) $\geq$ 30 is considered "yes" forecast of precipitation ($\geq$ .01 inch). All stations with an (NPOP) $\geq$ 30 are considered as a "yes" climatological forecast of precipitation.

Figure 39 is a plot off the calendar year 1987 monthly mean Gilman precipitation skill scores for the man, climatology, and NMC/NWP model precipitation forecasts verifying on days 3, 4, and 5 after forecast day. (See Appendix C for an explanation of this score.)

Figure 40 is a plot of the 18 year (1970-1987) average monthly mean Gilman precipitation skill scores for the man and climatology precipitation forecasts verifying on days 3, 4, and 5 after forecast day.

Figure 41 is a plot of the 1970 through 1987 calendar year Gilman precipitation skill scores for the man and climatology precipitation forecasts verifying on days 3, 4, and 5 after forecast day.

Figure 42 is a plot of the 1970 through 1987 Gilman precipitation skill scores for the man and climatology precipitation forecasts verifying on days (3+4+5) -- after forecast day.

Figure 43 is similar to figure 38 except the skill score is Hughes. (See Appendix D for an explanation of this score.)

Figure 44 is similar to figure 39 except the average is for 11 years, the skill score is Hughes, and climatology is not depicted.

Figure 45 is similar to figure 40 except the calendar years are 1977 through 1987 and the skill score is Hughes.

Figure 46 is similar to figure 38 except the skill score is Hughes Probability. (See Appendix E for an explanation of this score.)

Figure 47 is similar to figure 39 except the average is for 10 years and the skill score is Hughes Probability.

Figure 48 is similar to figure 40 except the calendar years are 1978 through 1987 and the skill score is Hughes Probability.

Figure 49 is a plot of the calendar year 1987 monthly mean 3-class precipitation skill scores for the man and climatology mean precipitation forecasts verifying 1 to 5 days after forecast day. (See Appendix F for an explanation of this score.)

Figure 50 is a plot of the 10 year (1978-1987) average monthly mean 3-class precipitation skill scores for the man and climatology mean precipitation forecasts verifying 1 to 5 days after forecast day.

Figure 51 is a plot of the 1978 through 1987 calendar year 3-class precipitation skill scores for the man, NMC/NWP model and climatology mean precipitation forecast verifying 1 to 5 days after forecast day.

Figure 52 is similar to figure 49 except the observed (P OBS - persistence of the 5 day mean observed precipitation as a 6-10 forecast) is depicted and the forecast is for 6 to 10 days.

Figure 53 is similar to figure 50 except the forecast is for 6 to 10 days.

Figure 54 is similar to figure 51 except the forecast is for 6 to 10 days.

Figures 55 through 58 are plots of the calendar year 1987 seasonal mean standardized correlation scores for the NMC/NWP model North American area mean sea-level pressure and 500mb progs verifying on days 1 through 9 after forecast day.

SECTION 1

Man & Machine (NMC/NWP Guidance)

Mean Sea Level Pressure and 500 MB Correlation Scores

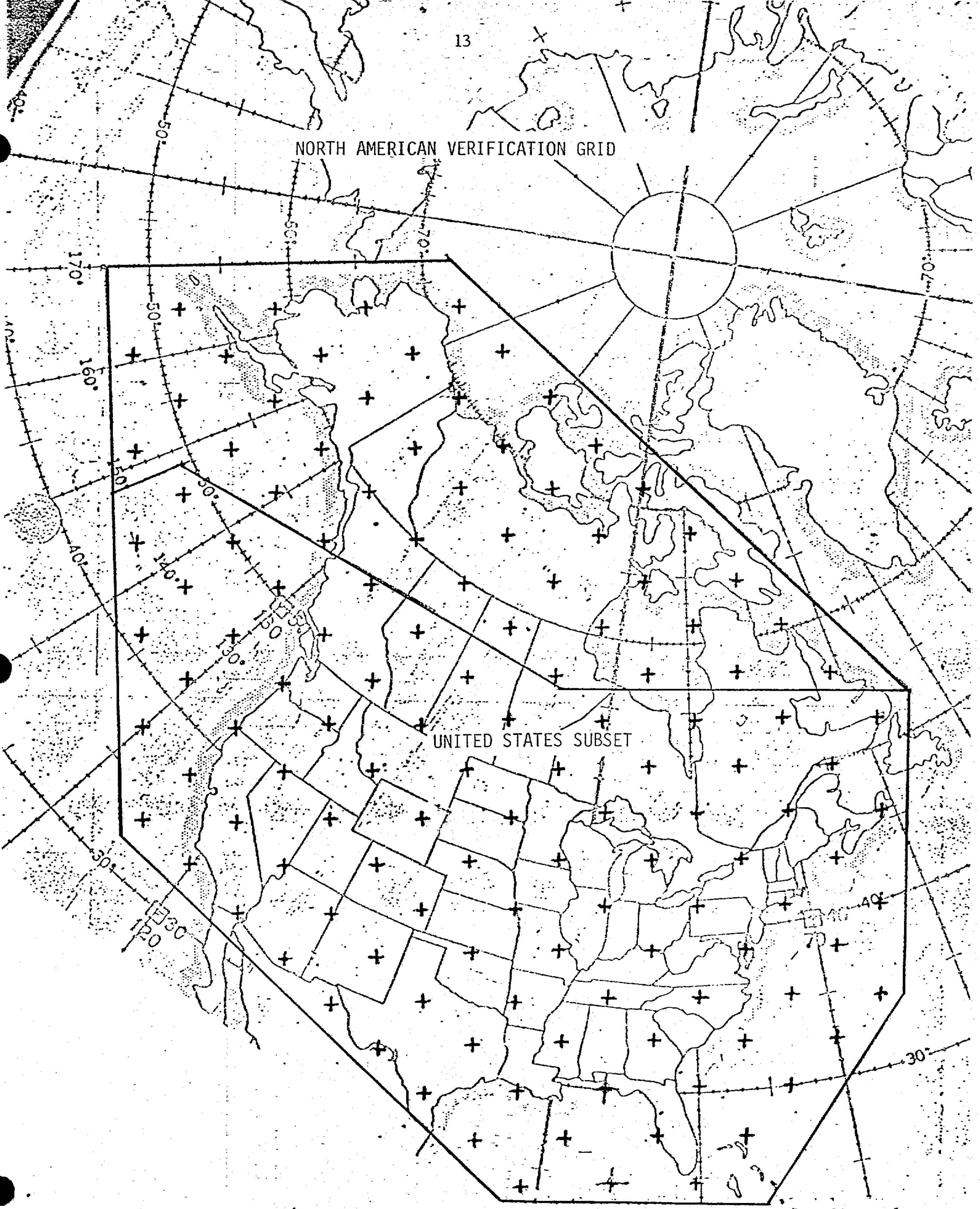
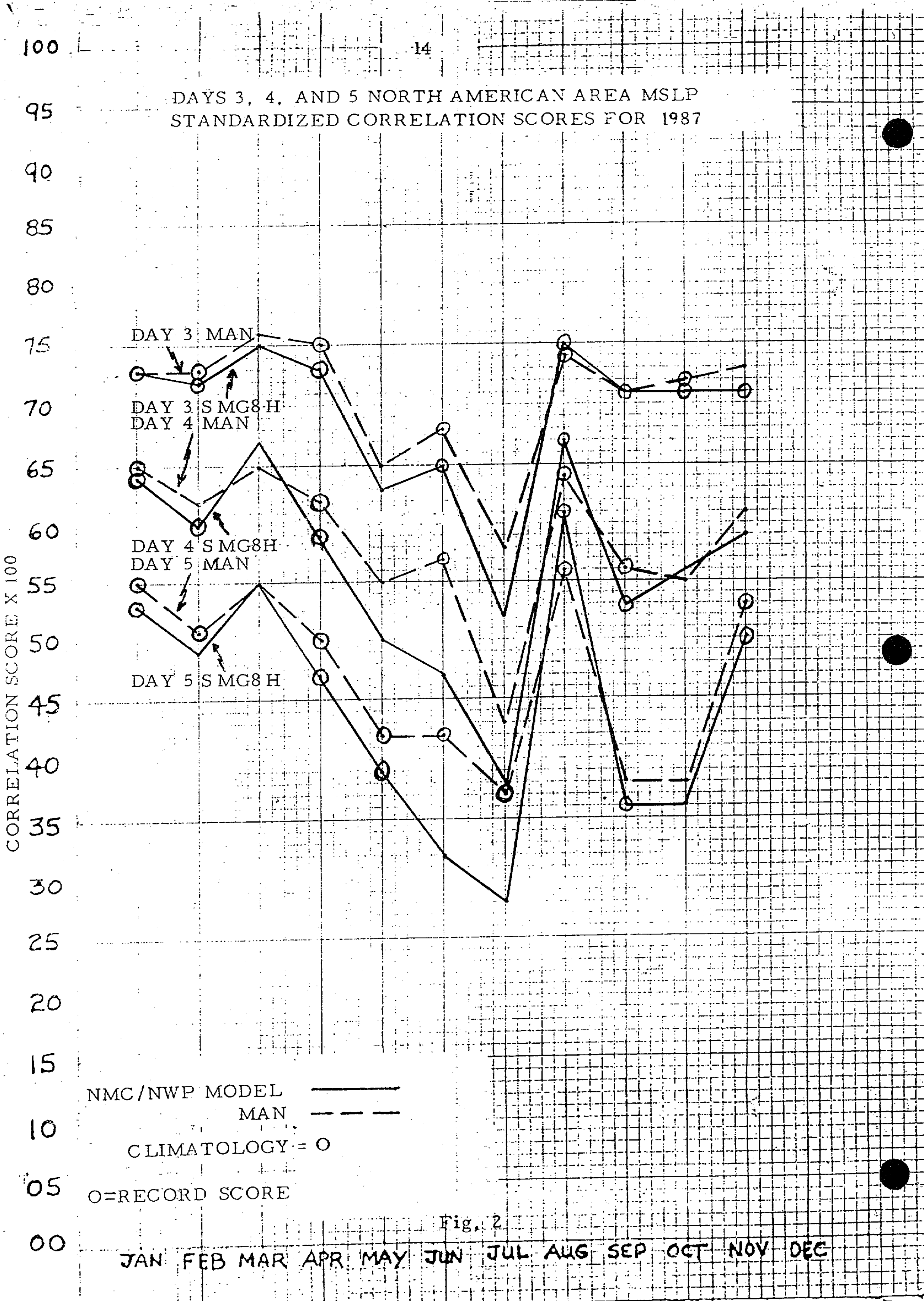


Fig 1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STANDARDIZED CORRELATION SCORES FOR 1987
CORRELATION SCORE X 100
100
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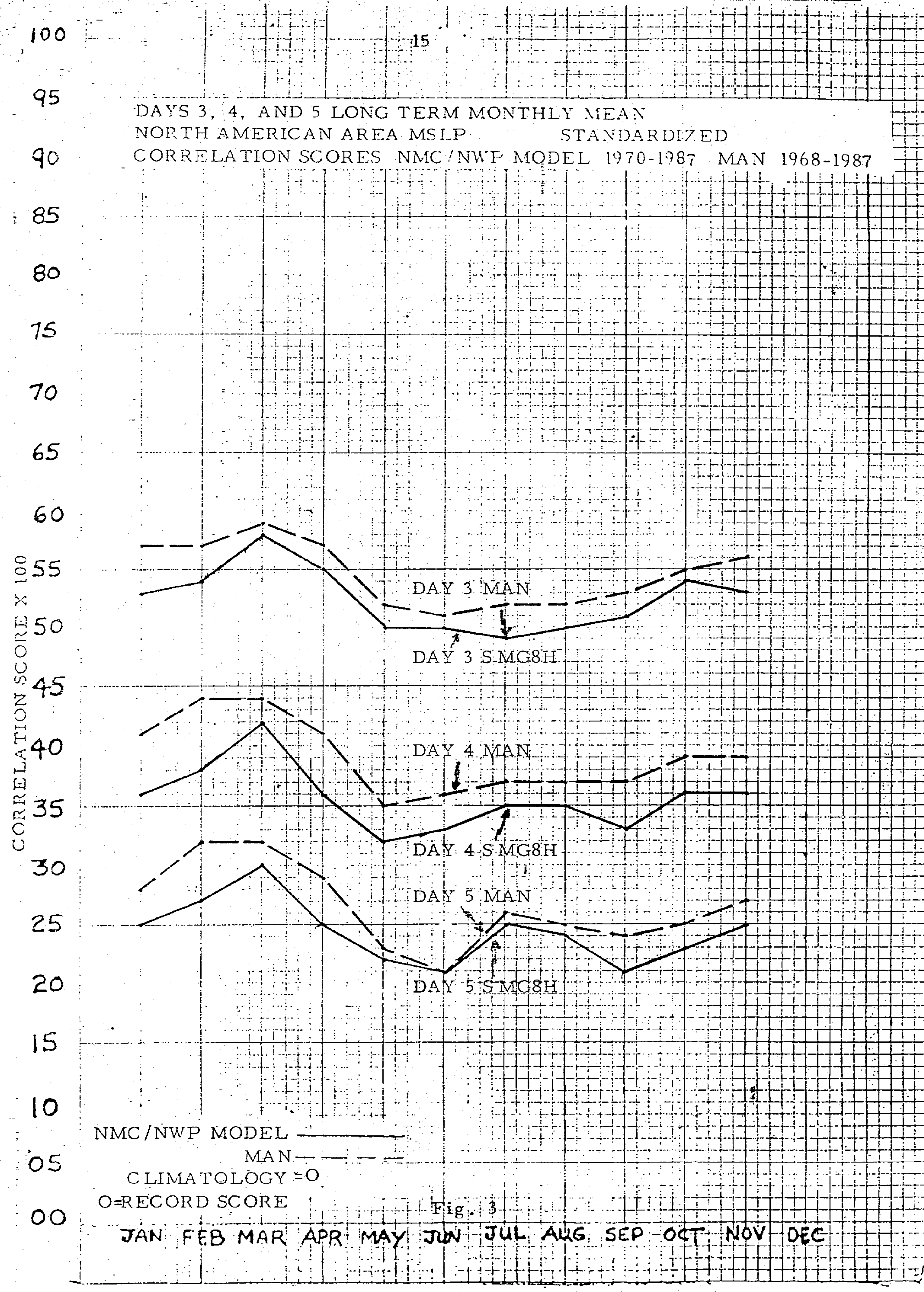
DAY 5 MAN
DAY 5 S MG8 H
NMC/NWP MODEL
MAN
CLIMATOLOGY = O
O=RECORD SCORE
JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC

Fig. 2


DAYS 3, 4, AND 5 LONG TERM MONTHLY MEAN
NORTH AMERICAN AREA MSLP STANDARDIZED
CORRELATION SCORES NMC/NWP MODEL 1970-1987 MAN 1968-1987
CORRELATION SCORE X 100
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DAY 4 SMG8H
DAY 5 MAN
DAY 5 SMG8H
NMC/NWP MODEL
MAN
CLIMATOLOGY =O
O=RECORD SCORE
JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC

Fig. 3

NMC/NWP MODEL CALENDAR YEAR AVERAGE
NORTH AMERICAN AREA MSLP STANDARDIZED
CORRELATION SCORES FOR DAYS 3, 4, AND 5 PROGS

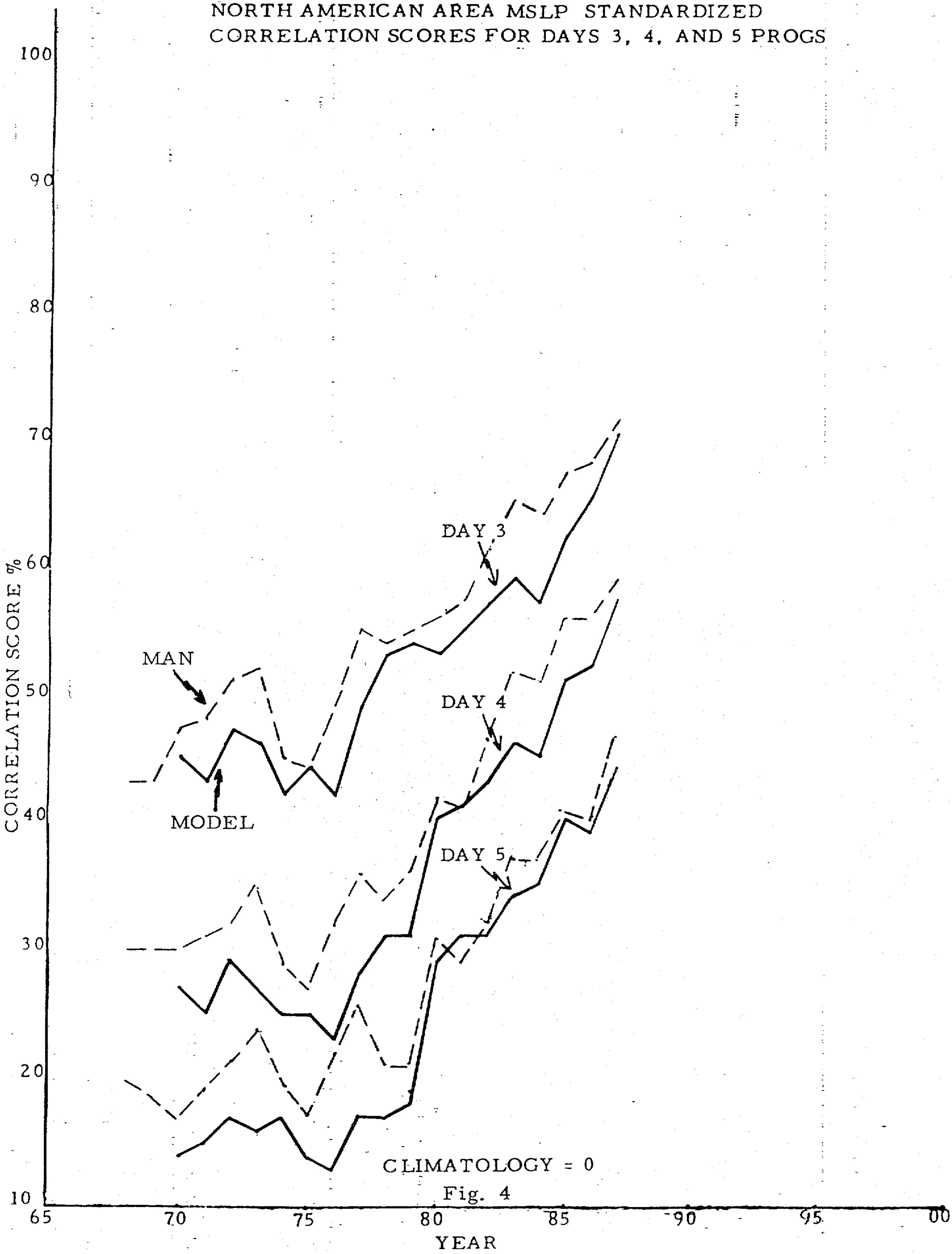
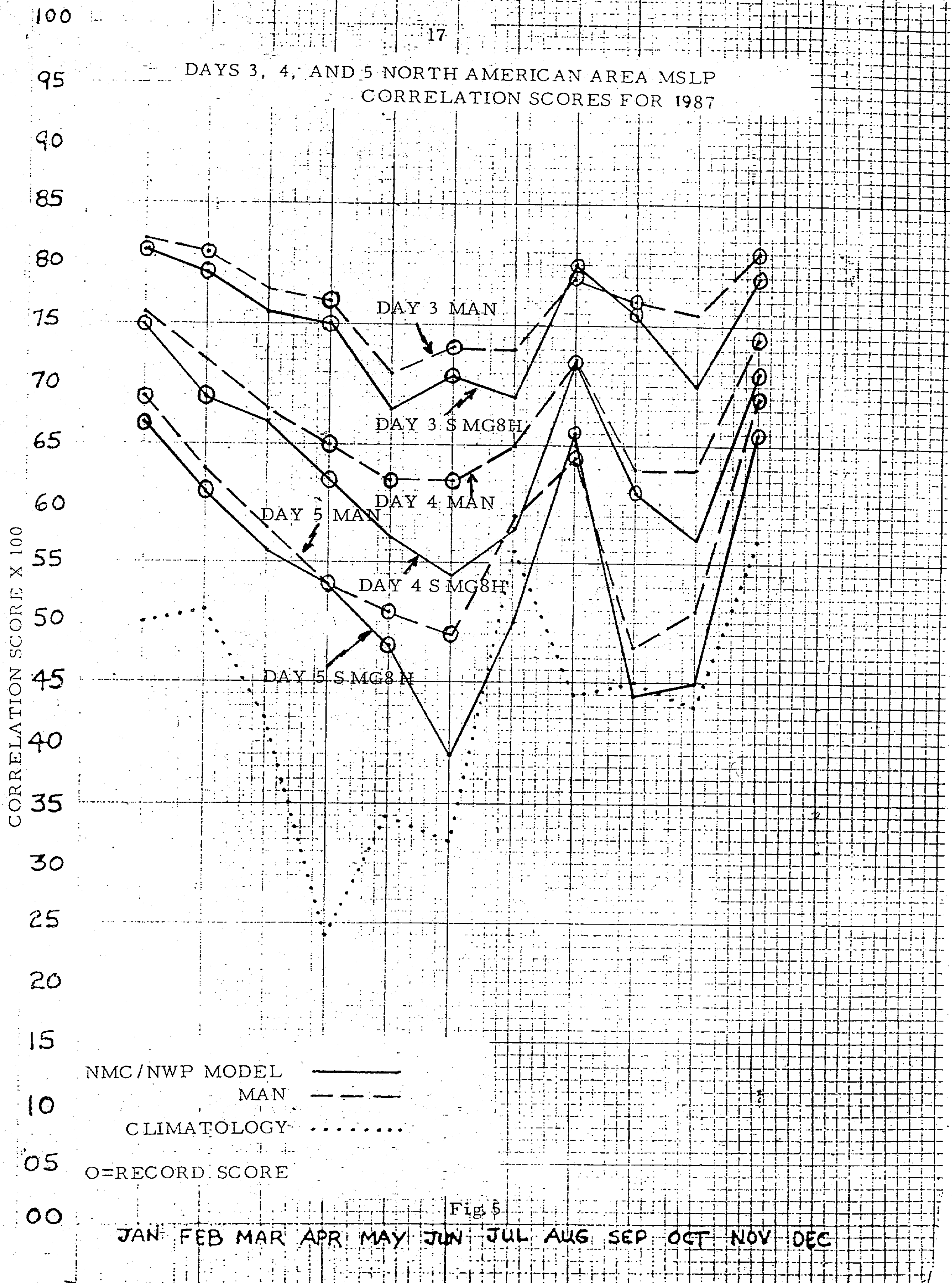


Fig. 4


DAYS 3, 4, AND 5 NORTH AMERICAN AREA MSLP
CORRELATION SCORES FOR 1987
CORRELATION SCORE X 100
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NMC/NWP MODEL
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CLIMATOLOGY
O=RECORD SCORE
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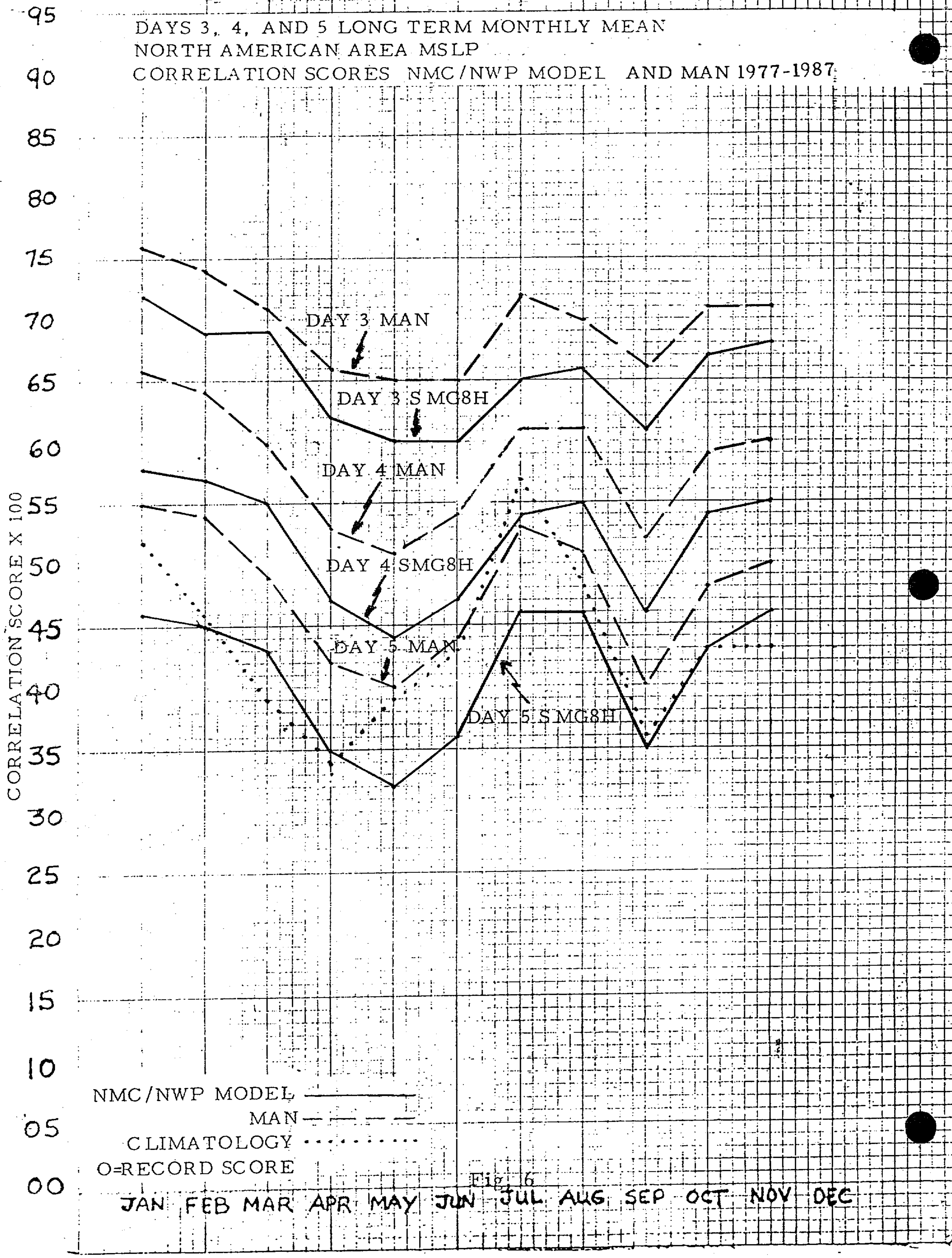
Fig. 5


DAYS 3, 4, AND 5 LONG TERM MONTHLY MEAN
NORTH AMERICAN AREA MSLP
CORRELATION SCORES NMC/NWP MODEL AND MAN 1977-1987
CORRELATION SCORE X 100
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DAY 4 SMG8H
DAY 5 MAN
DAY 5 S MG8H
NMC/NWP MODEL
MAN
CLIMATOLOGY
O=RECORD SCORE
JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC

Fig. 6

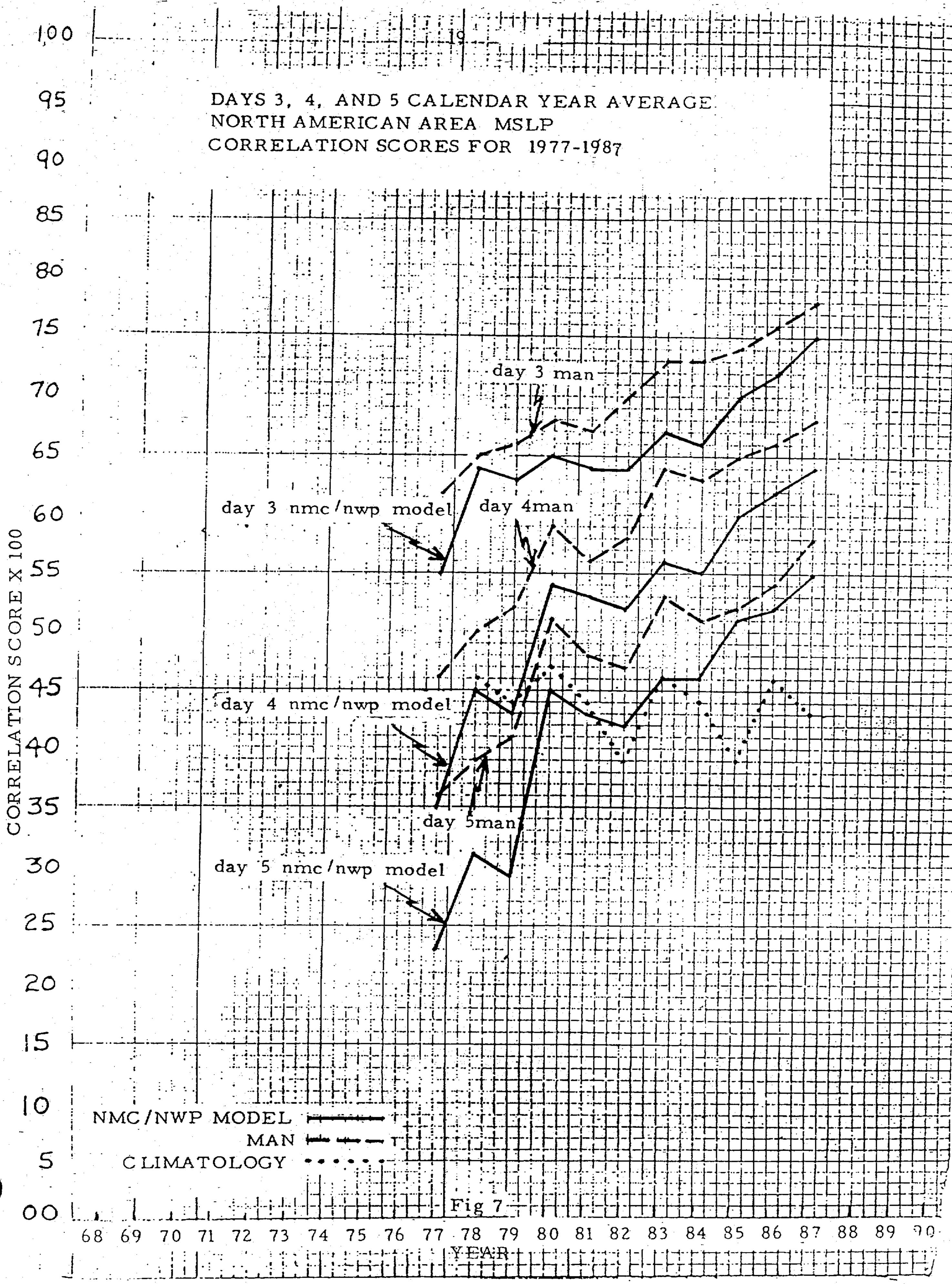
DAYS 3, 4, AND 5 CALENDAR YEAR AVERAGE
NORTH AMERICAN AREA MSLP
CORRELATION SCORES FOR 1977-1987
CORRELATION SCORE X 100
day 3 man
day 3 nmc/nwp model
day 4man
day 4 nmc/nwp model
day 5man
day 5 nmc/nwp model
NMC/NWP MODEL
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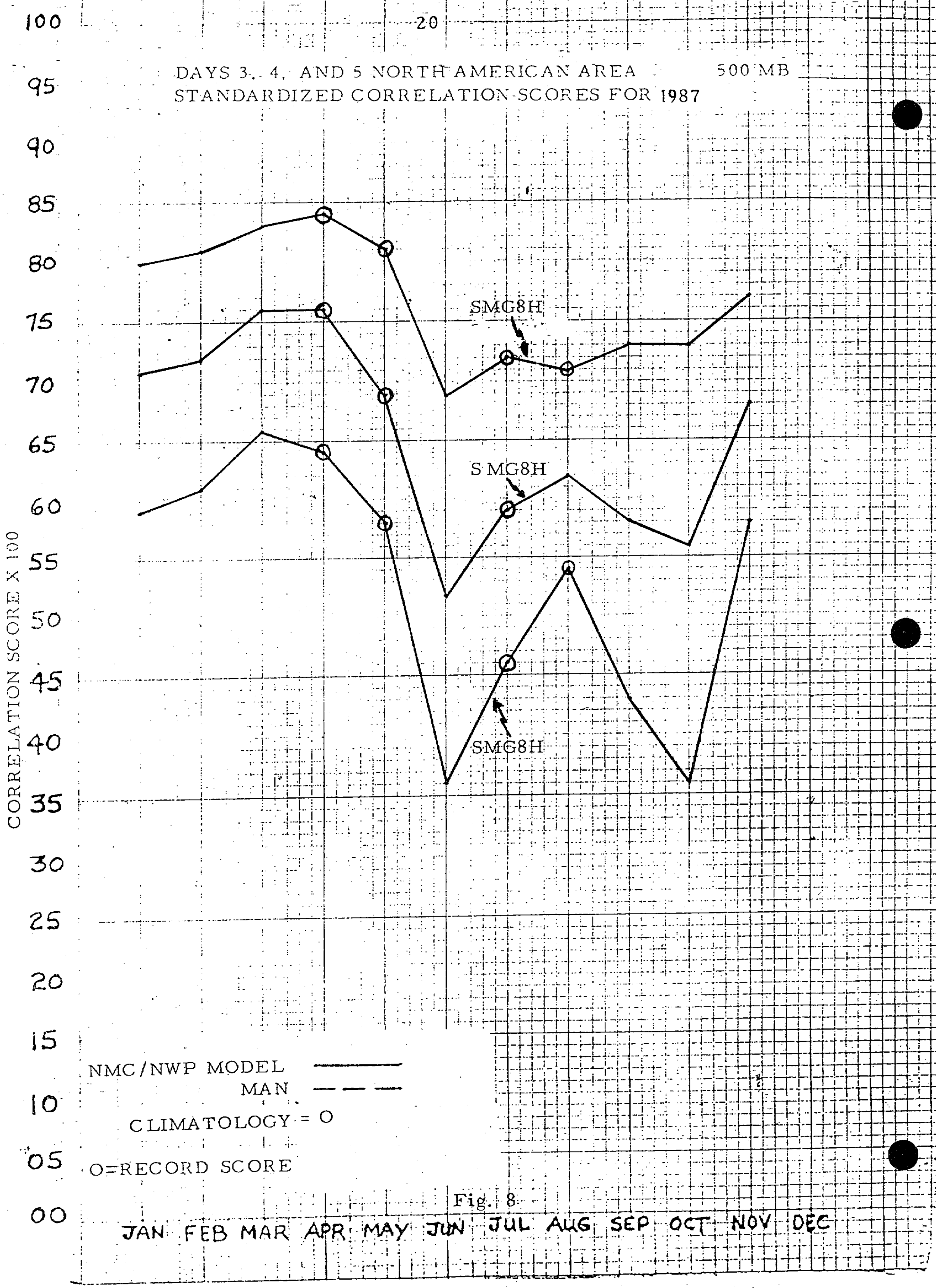
Fig 7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CORRELATION SCORE X 100
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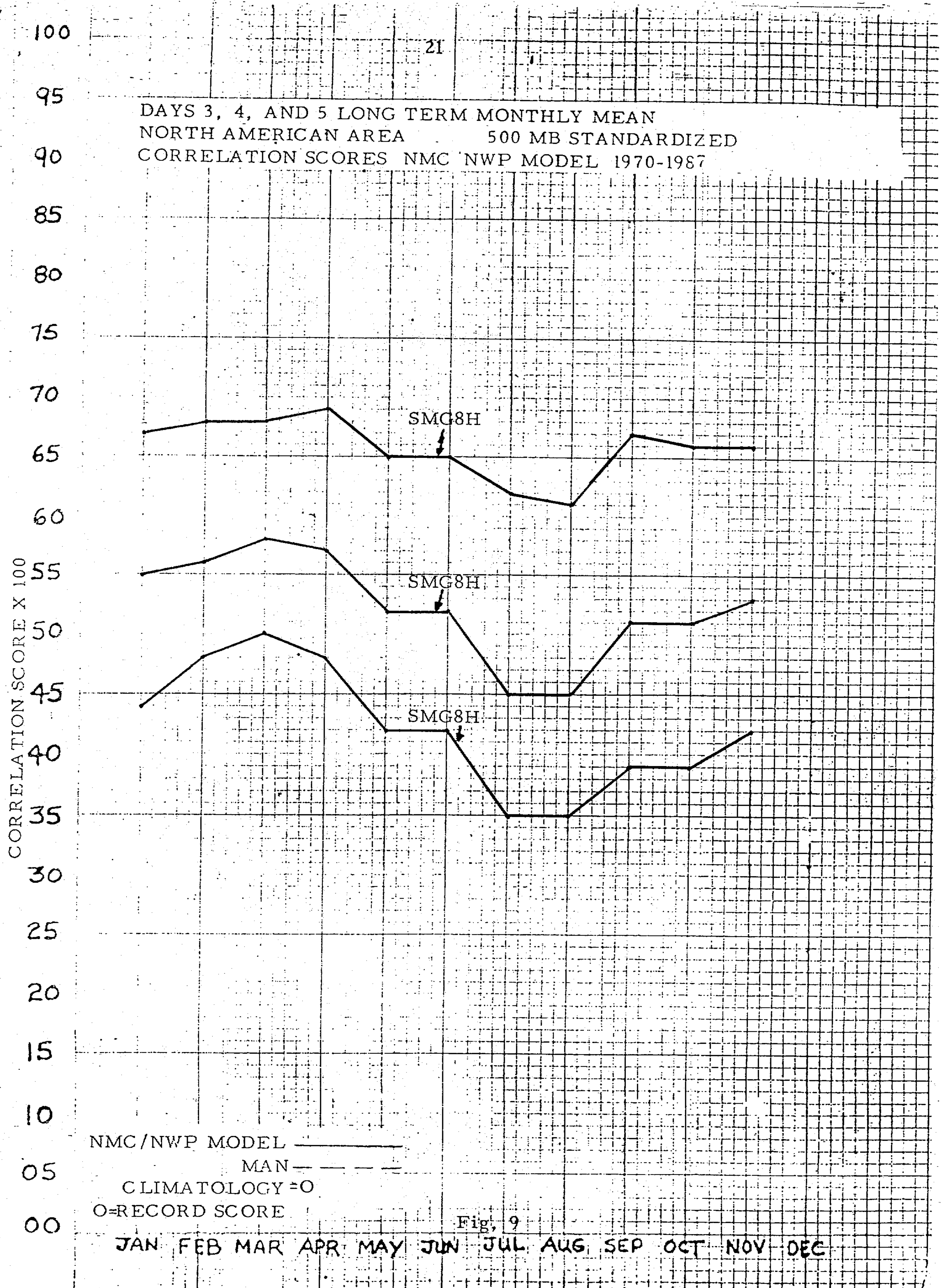
SMG8H
NMC/NWP MODEL
MAN
CLIMATOLOGY = O
O=RECORD SCORE
JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC

Fig. 8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NORTH AMERICAN AREA
500 MB STANDARDIZED
CORRELATION SCORES NMC NWP MODEL 1970-1987
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SMG8H
SMG8H
CORRELATION SCORE X 100
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NMC/NWP MODEL
MAN
CLIMATOLOGY =O
O=RECORD SCORE
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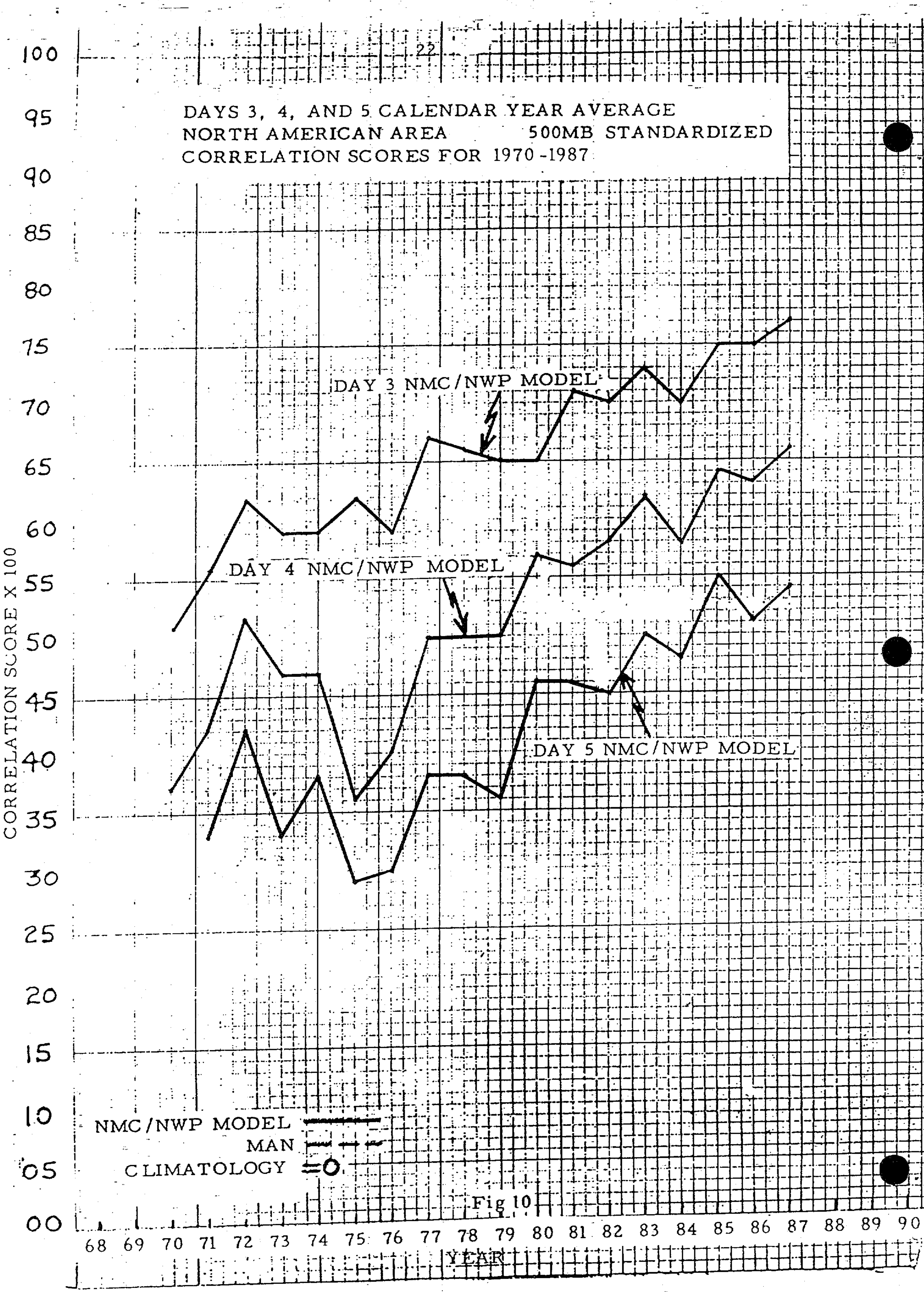
Fig. 9


DAYS 3, 4, AND 5 CALENDAR YEAR AVERAGE
NORTH AMERICAN AREA
500MB STANDARDIZED
CORRELATION SCORES FOR 1970-1987
DAY 3 NMC/NWP MODEL
DAY 4 NMC/NWP MODEL
DAY 5 NMC/NWP MODEL
CORRELATION SCORE X 100
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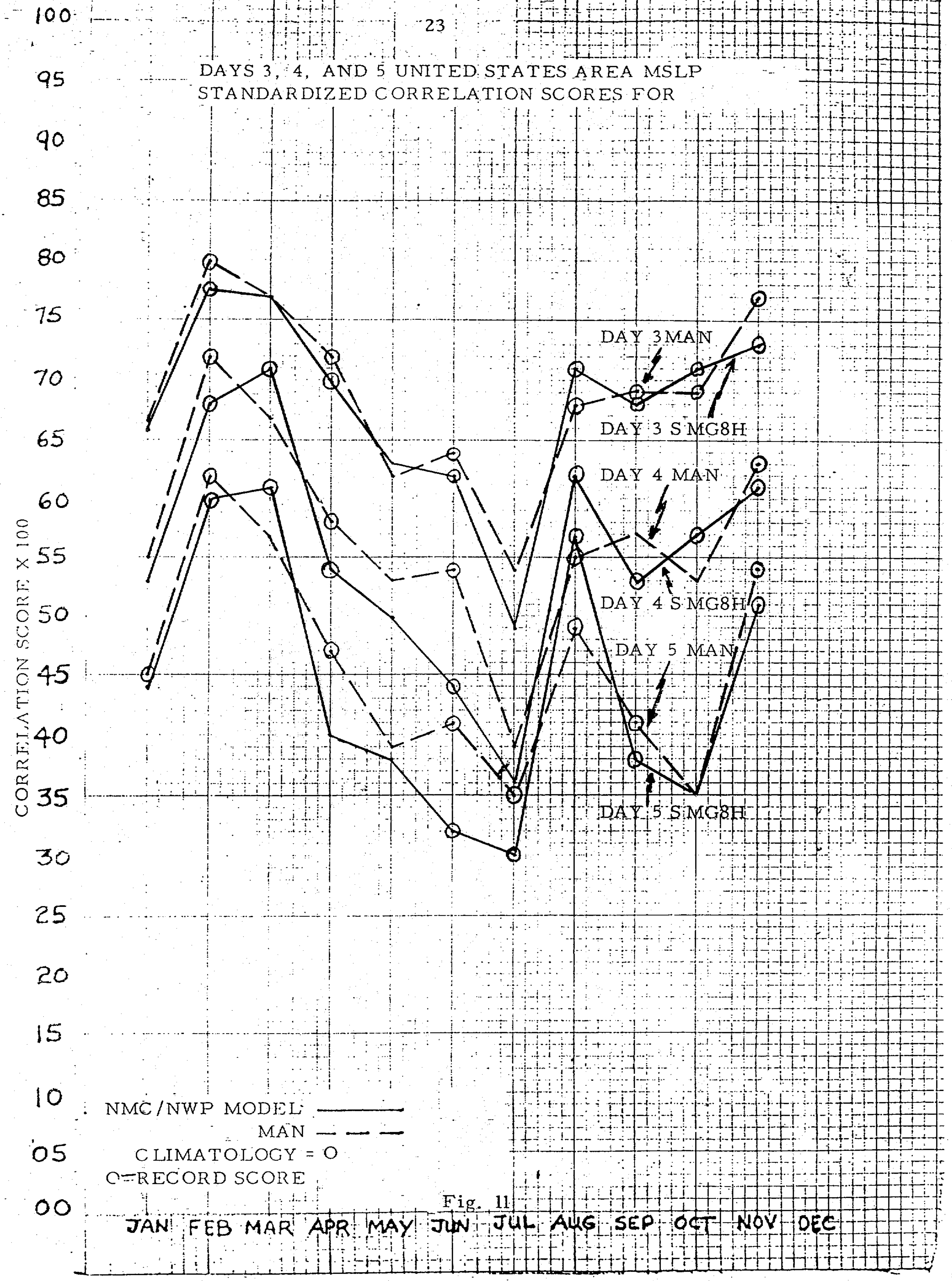
NMC/NWP MODEL
MAN
CLIMATOLOGY
68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90
YEAR

Fig 10


DAYS 3, 4, AND 5 UNITED STATES AREA MSLP
STANDARDIZED CORRELATION SCORES FOR
CORRELATION SCORE X 100
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NMC/NWP MODEL
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CLIMATOLOGY = O
⊘=RECORD SCORE
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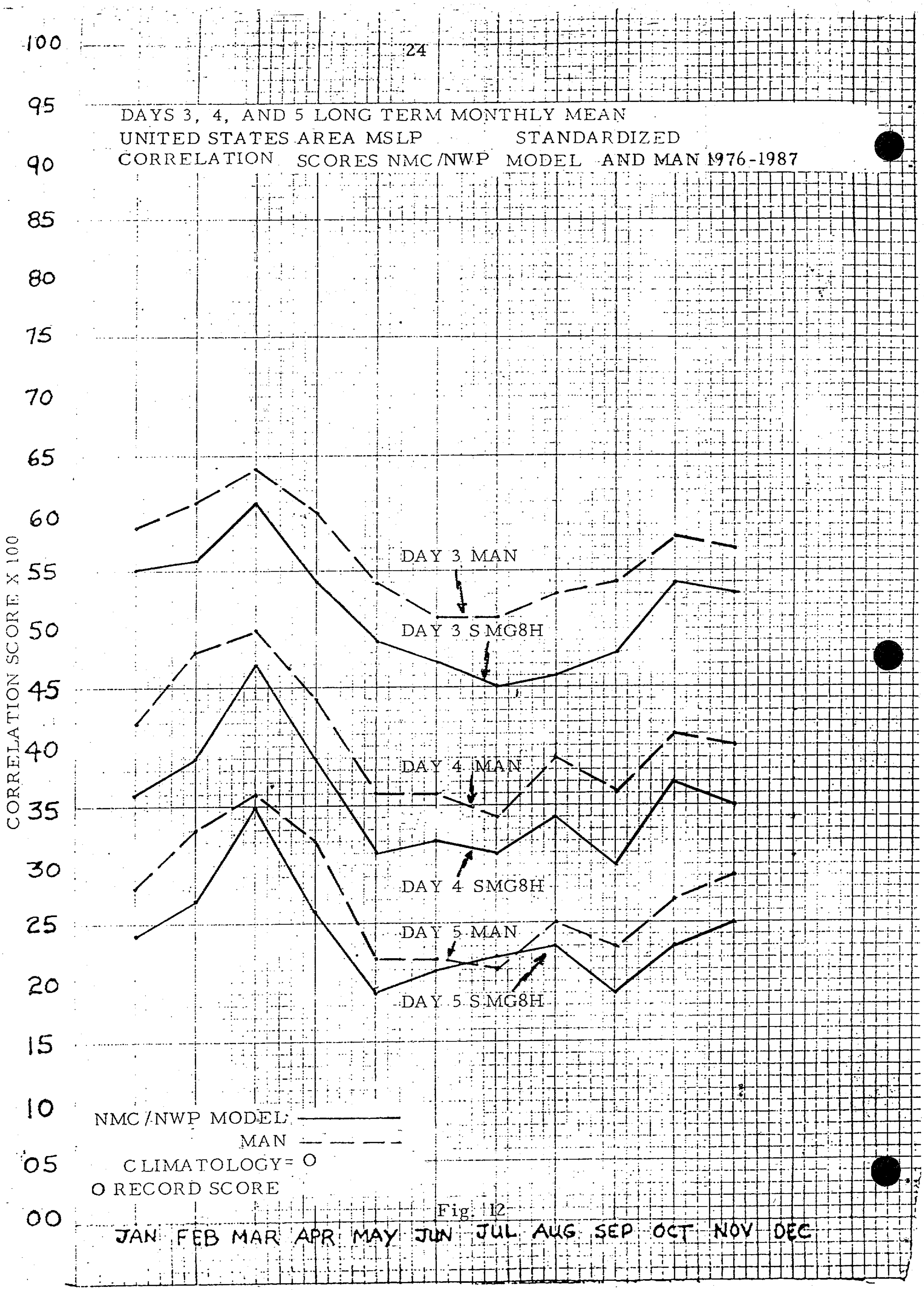
Fig. 11


DAYS 3, 4, AND 5 LONG TERM MONTHLY MEAN
UNITED STATES AREA MSLP STANDARDIZED
CORRELATION SCORES NMC/NWP MODEL AND MAN 1976-1987
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CORRELATION SCORE X 100
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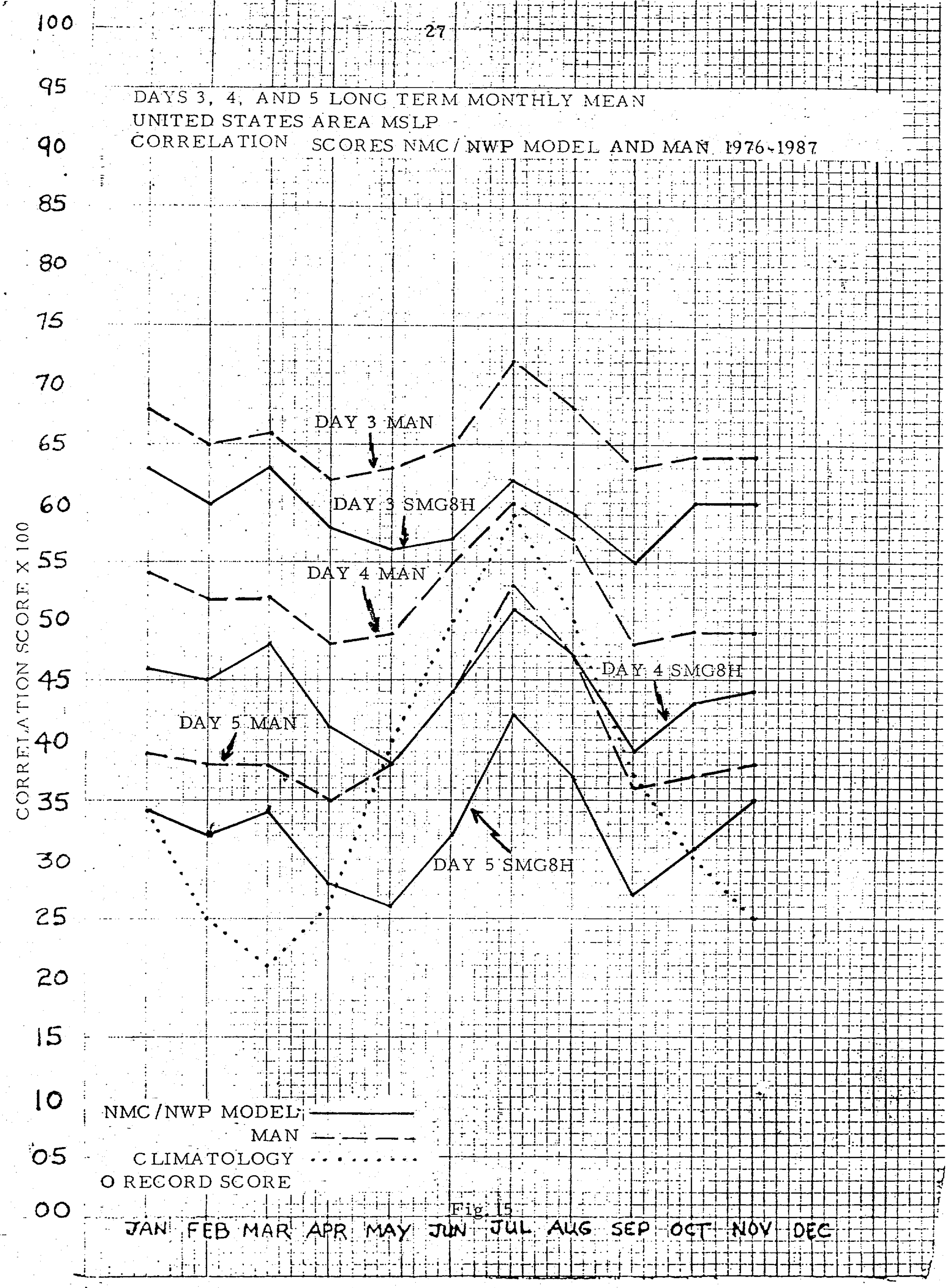
DAY 3 SMG8H
DAY 4 MAN
DAY 4 SMG8H
DAY 5 MAN
DAY 5 SMG8H
NMC/NWP MODEL
MAN
CLIMATOLOGY= O
O RECORD SCORE
JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC

Fig. 12


DAYS 3, 4, AND 5 LONG TERM MONTHLY MEAN
UNITED STATES AREA MSLP
CORRELATION SCORES NMC/NWP MODEL AND MAN 1976-1987
CORRELATION SCORE X 100
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DAY 3 MAN
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DAY 5 SMG8H
NMC/NWP MODEL
MAN
CLIMATOLOGY
O RECORD SCORE
JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC

Fig. 15

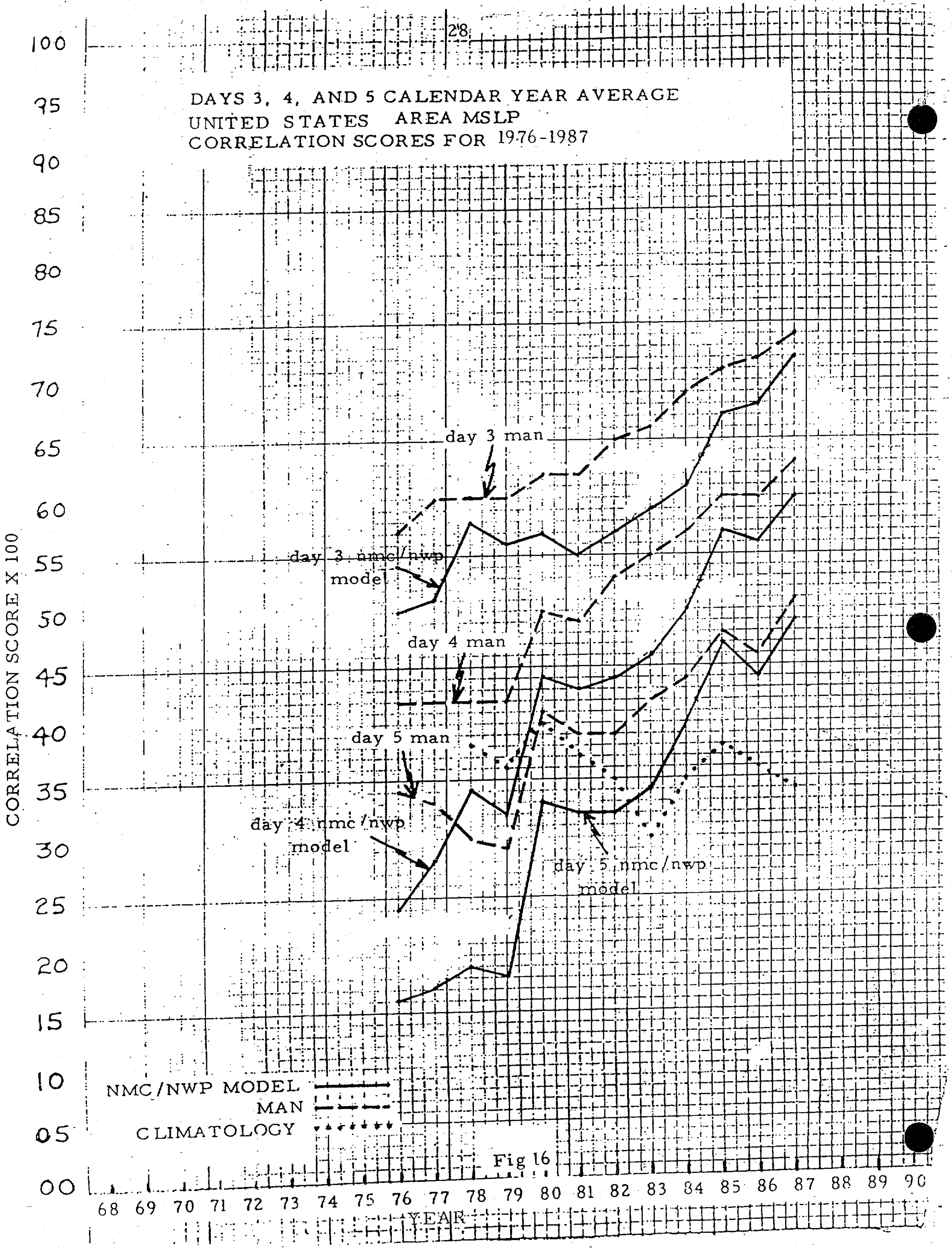
DAYS 3, 4, AND 5 CALENDAR YEAR AVERAGE
UNITED STATES AREA MSLP
CORRELATION SCORES FOR 1976-1987
CORRELATION SCORE X 100
day 3 man
day 3 nmc/nwp model
day 4 man
day 5 man
day 4 nmc/nwp model
day 5 nmc/nwp model
NMC/NWP MODEL
MAN
CLIMATOLOGY
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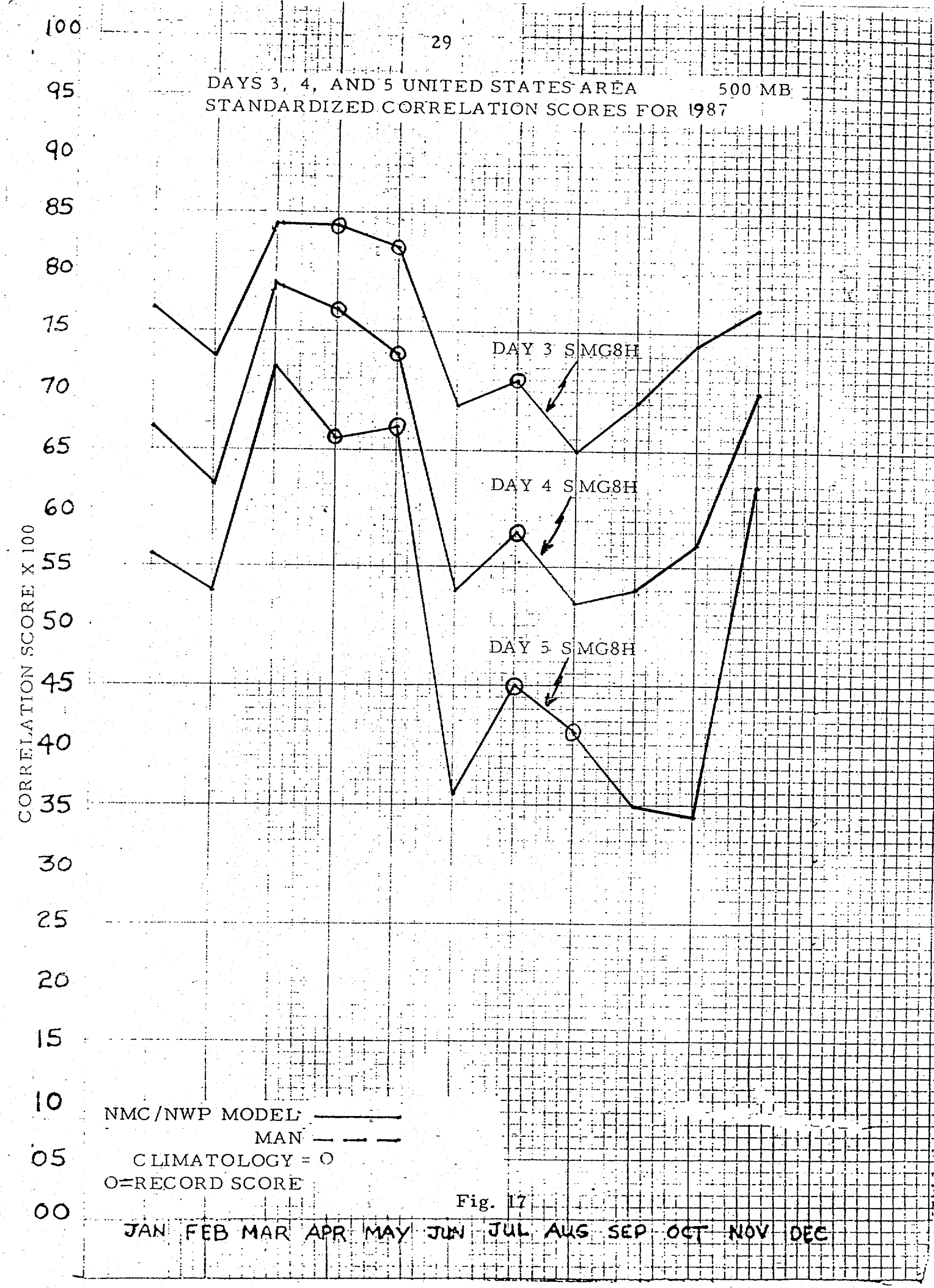
Fig 16



DAYS 3, 4, AND 5 UNITED STATES AREA 500 MB
STANDARDIZED CORRELATION SCORES FOR 1987
CORRELATION SCORE X 100
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DAY 3 SMG8H
DAY 4 SMG8H
DAY 5 SMG8H
NMC/NWP MODEL
MAN
CLIMATOLOGY = O
O=RECORD SCORE
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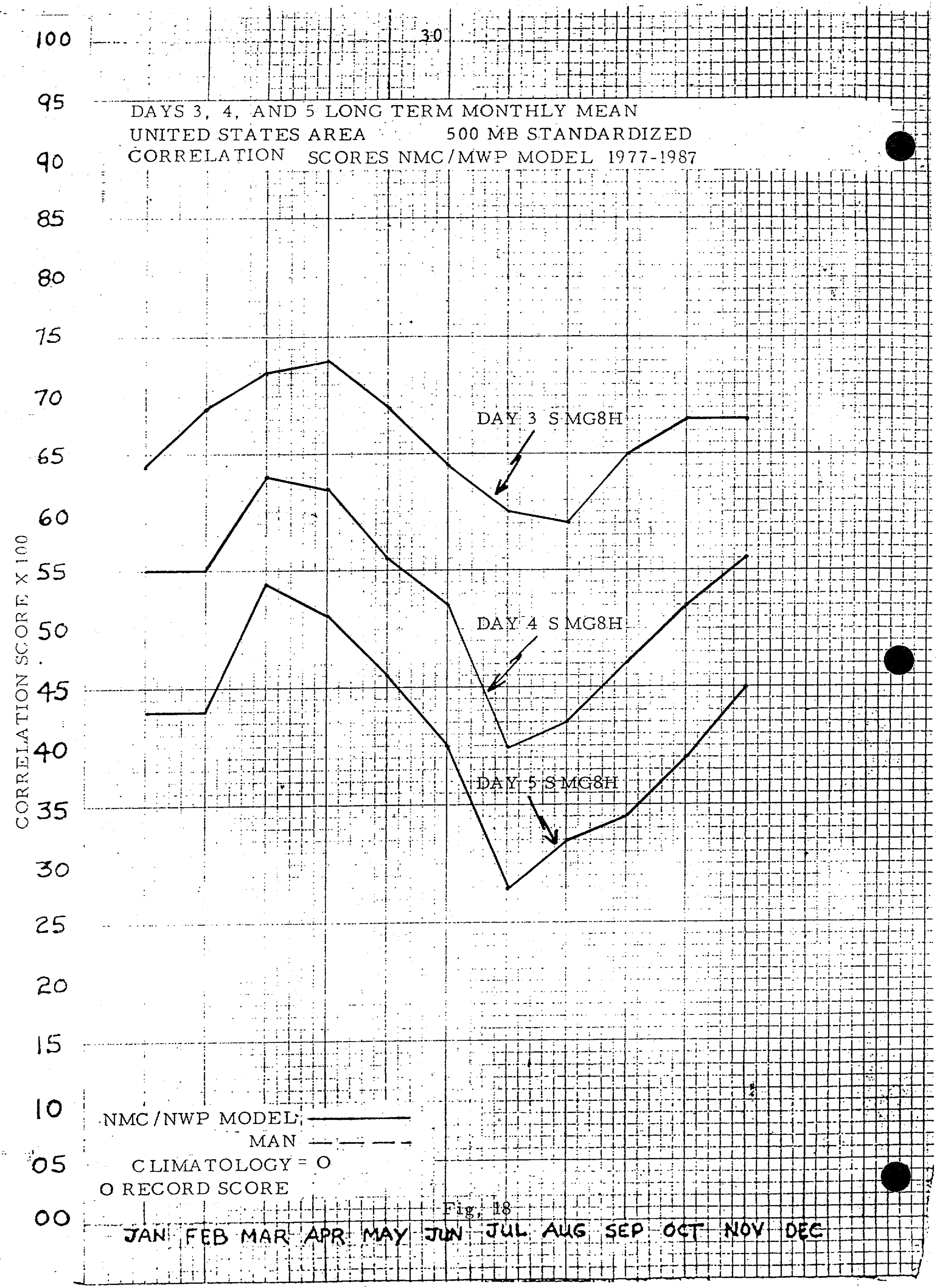
Fig. 17


DAYS 3, 4, AND 5 LONG TERM MONTHLY MEAN
UNITED STATES AREA 500 MB STANDARDIZED
CORRELATION SCORES NMC/MWP MODEL 1977-1987
CORRELATION SCORE X 100
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DAY 3 S MG8H
DAY 4 S MG8H
DAY 5 S MG8H
NMC/NWP MODEL
MAN
CLIMATOLOGY = O
O RECORD SCORE
JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC

Fig. 18

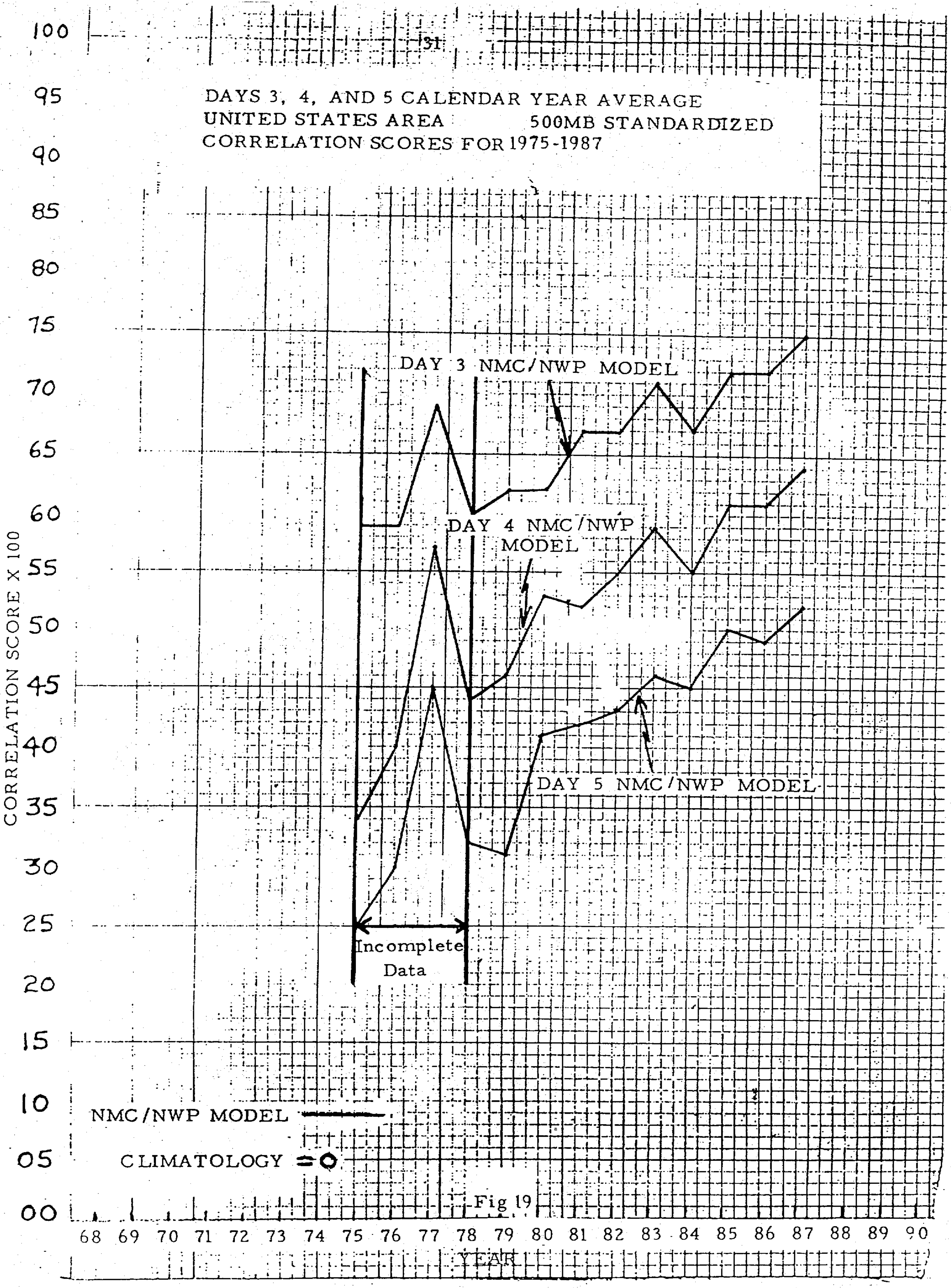

DAYS 3, 4, AND 5 CALENDAR YEAR AVERAGE
UNITED STATES AREA 500MB STANDARDIZED
CORRELATION SCORES FOR 1975-1987
DAY 3 NMC/NWP MODEL
DAY 4 NMC/NWP MODEL
DAY 5 NMC/NWP MODEL
Incomplete Data
NMC/NWP MODEL
CLIMATOLOGY = O
CORRELATION SCORE X 100
100
95
90
85
80
75
70
65
60
55
50
45
40
35
30
25
20
15
10
05
00
68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90
YEAR

Fig 19

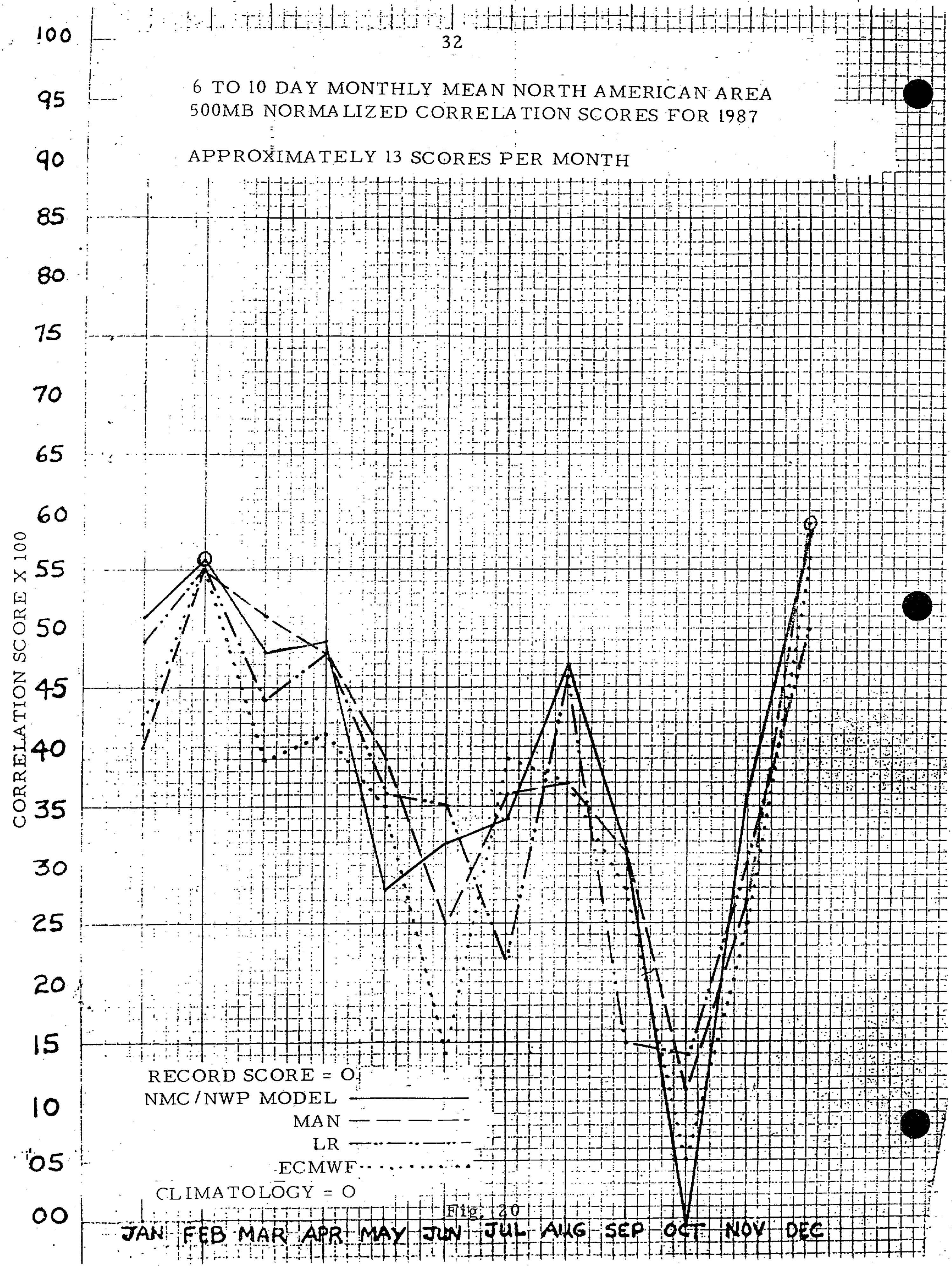

6 TO 10 DAY MONTHLY MEAN NORTH AMERICAN AREA
500MB NORMALIZED CORRELATION SCORES FOR 1987
APPROXIMATELY 13 SCORES PER MONTH
CORRELATION SCORE X 100
100
95
90
85
80
75
70
65
60
55
50
45
40
35
30
25
20
15
10
05
00
RECORD SCORE = O
NMC/NWP MODEL
MAN
LR
ECMWF
CLIMATOLOGY = O
JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC

Fig. 20

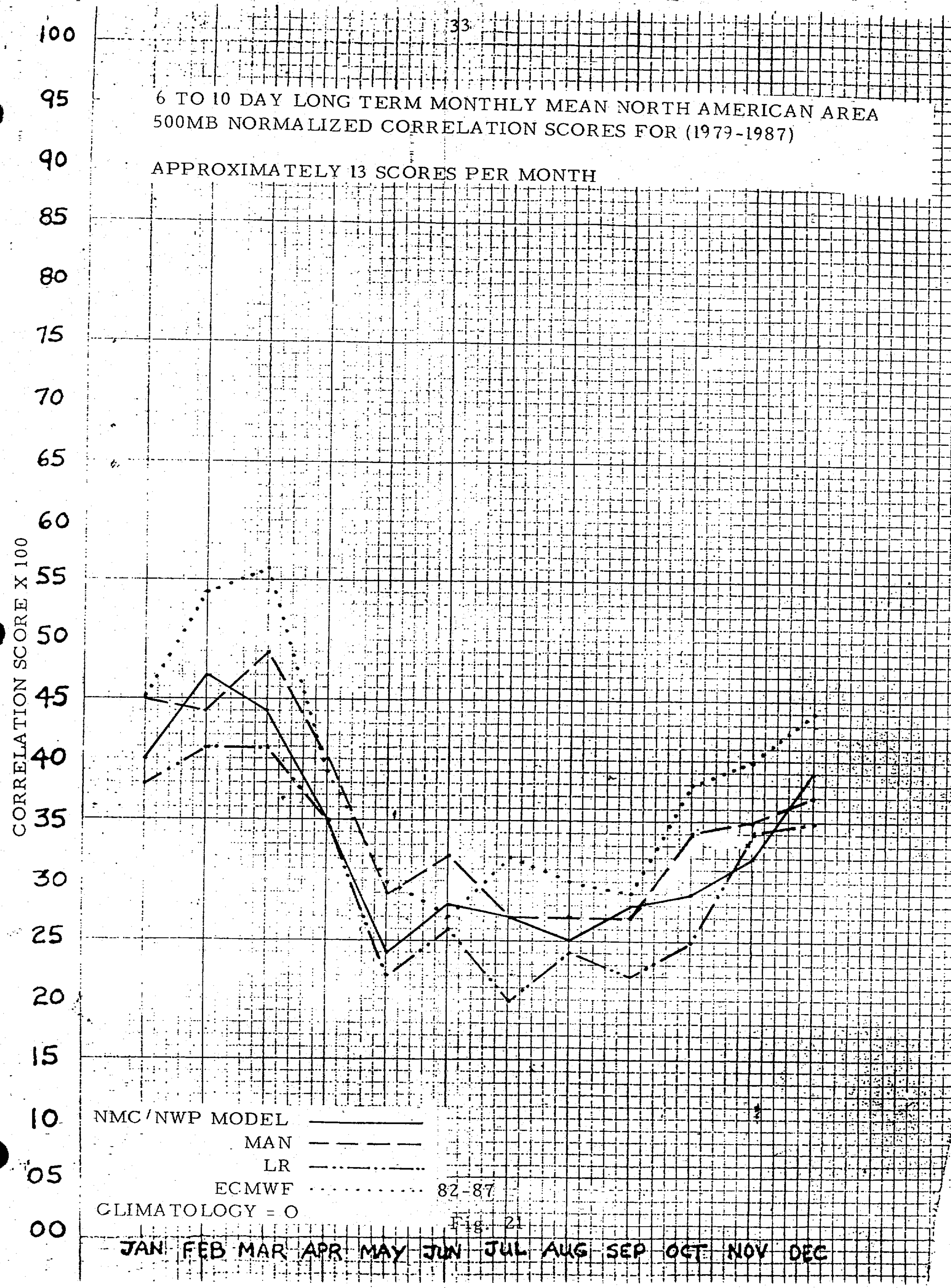

6 TO 10 DAY LONG TERM MONTHLY MEAN NORTH AMERICAN AREA
500MB NORMALIZED CORRELATION SCORES FOR (1979-1987)
APPROXIMATELY 13 SCORES PER MONTH
CORRELATION SCORE X 100
100
95
90
85
80
75
70
65
60
55
50
45
40
35
30
25
20
15
10
05
00
NMC/NWP MODEL
MAN
LR
ECMWF 82-87
CLIMATOLOGY = O
JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC

Fig. 21

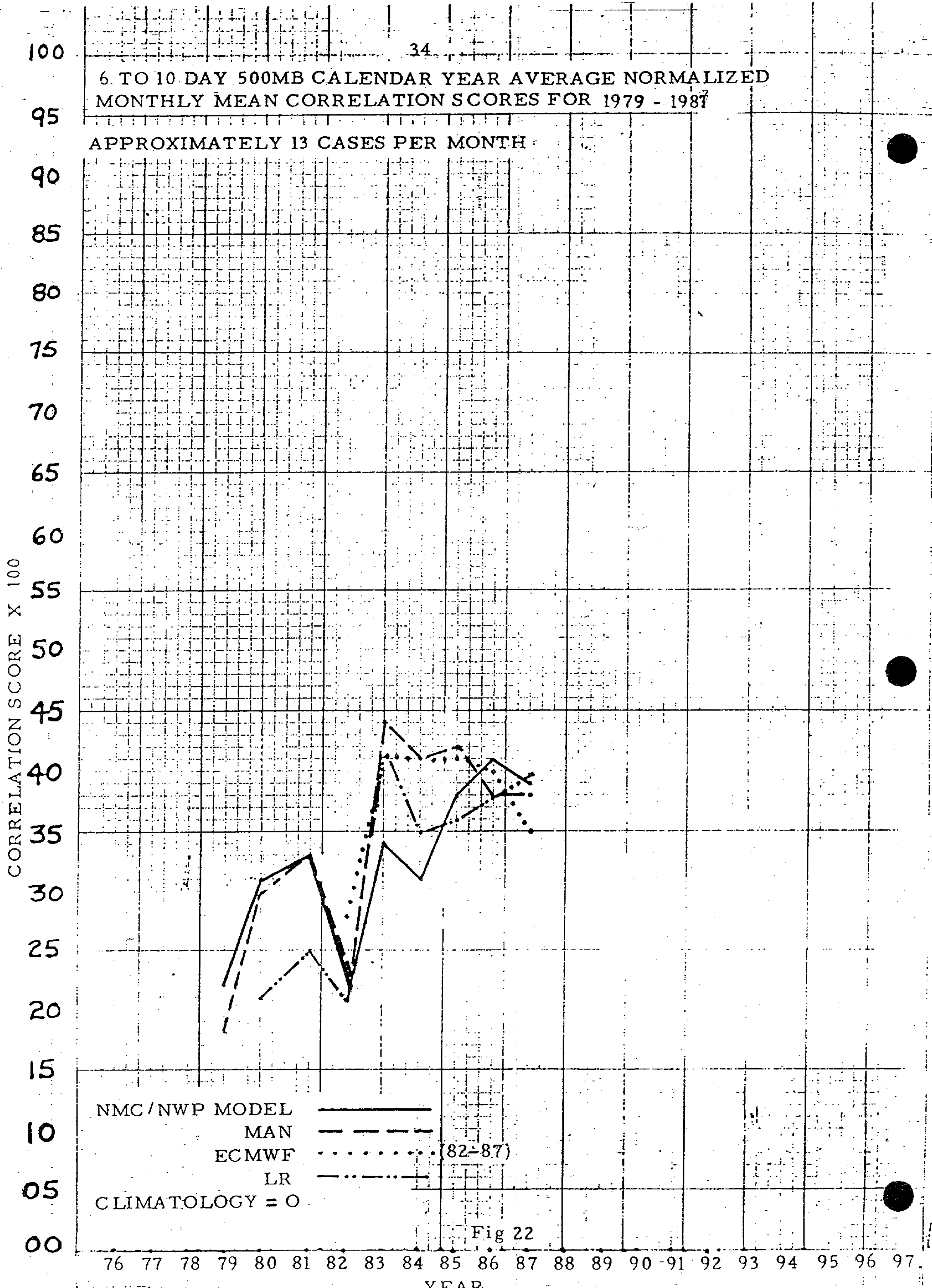
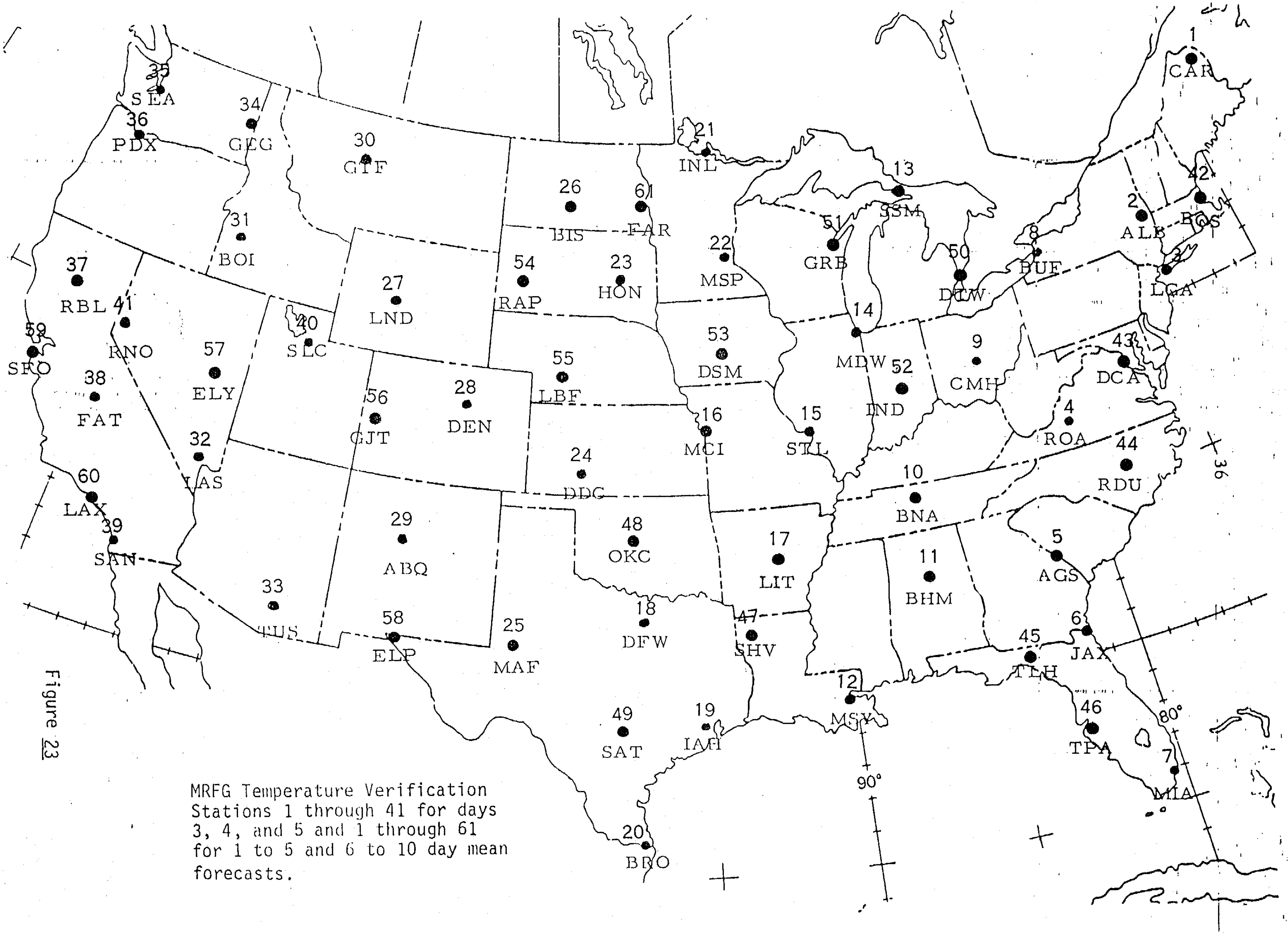

6 TO 10 DAY 500MB CALENDAR YEAR AVERAGE NORMALIZED MONTHLY MEAN CORRELATION SCORES FOR 1979 - 1987
APPROXIMATELY 13 CASES PER MONTH
CORRELATION SCORE X 100
100
95
90
85
80
75
70
65
60
55
50
45
40
35
30
25
20
15
10
05
00
NMC/NWP MODEL
MAN
ECMWF (82-87)
LR
CLIMATOLOGY = O
76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97
YEAR

Fig 22

SECTION 2

Man & Machine (KL Guidance)

Absolute Error Temperature Scores



MRFG Temperature Verification Stations 1 through 41 for days 3, 4, and 5 and 1 through 61 for 1 to 5 and 6 to 10 day mean forecasts.

Figure 23

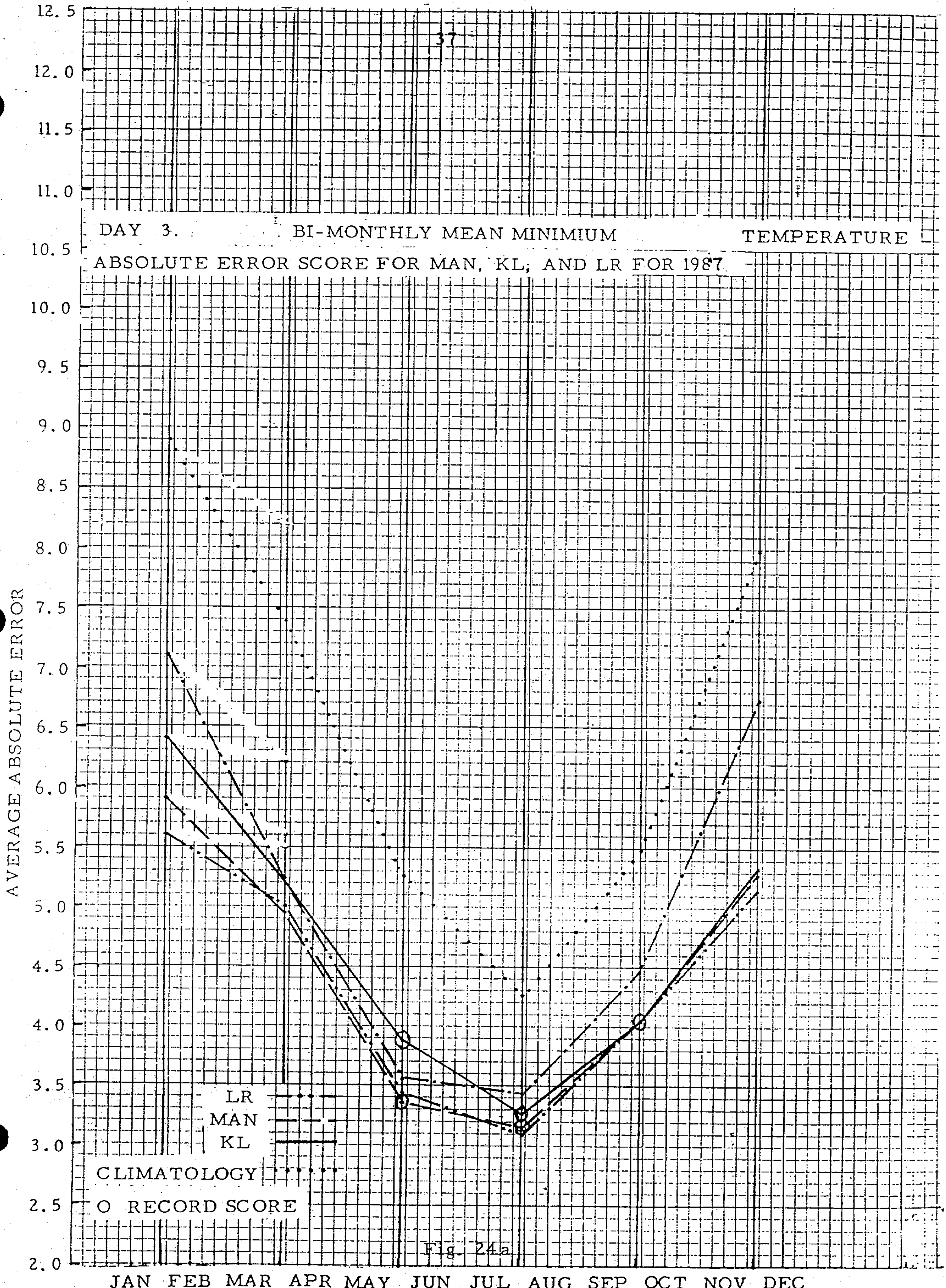

DAY 3. BI-MONTHLY MEAN MINIMIUM TEMPERATURE
ABSOLUTE ERROR SCORE FOR MAN, KL, AND LR FOR 1987
AVERAGE ABSOLUTE ERROR
12.5
12.0
11.5
11.0
10.5
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
LR
MAN
KL
CLIMATOLOGY
O RECORD SCORE
JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC

Fig. 24a

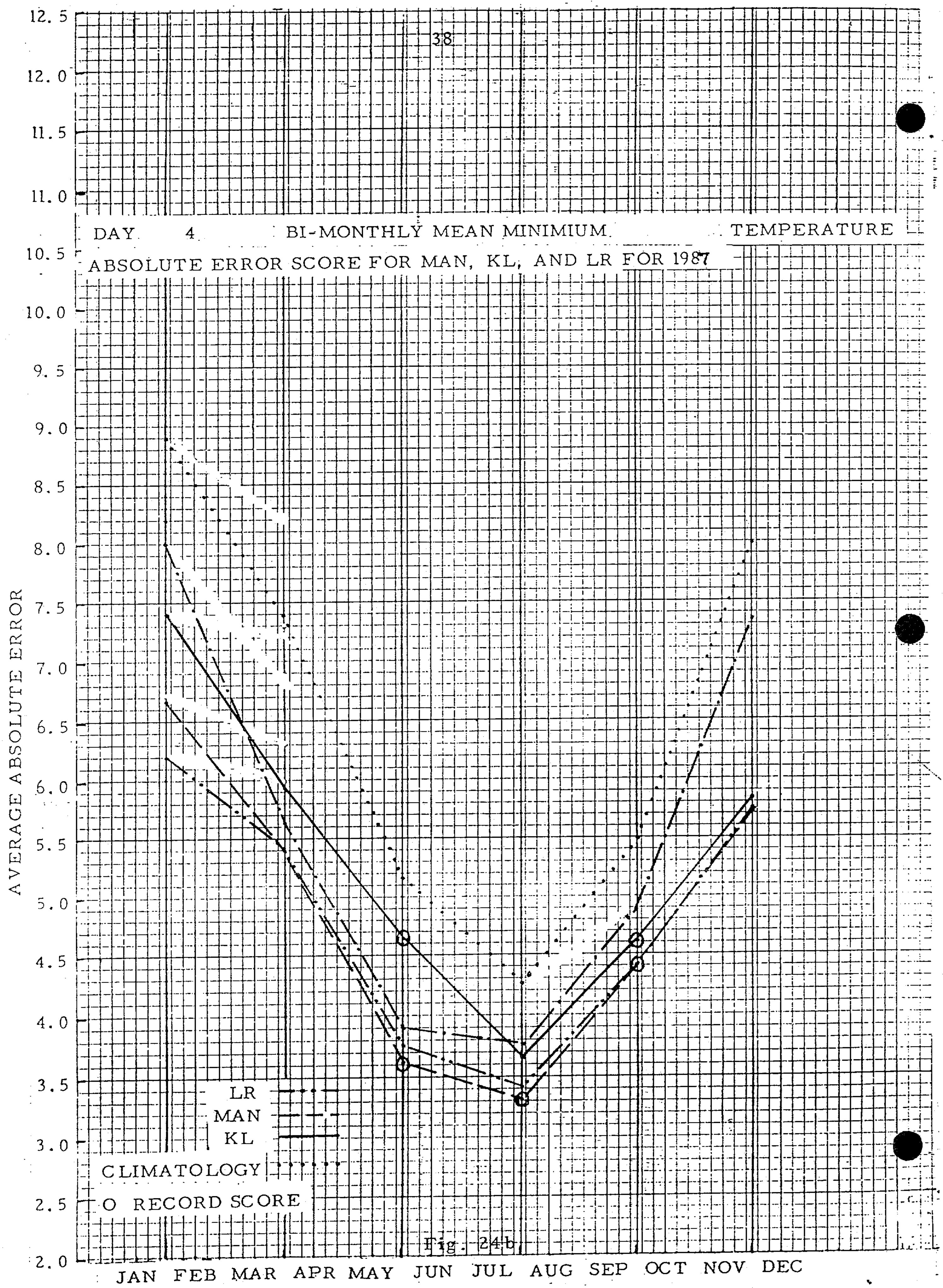

DAY 4 BI-MONTHLY MEAN MINIMUM TEMPERATURE
ABSOLUTE ERROR SCORE FOR MAN, KL, AND LR FOR 1987
AVERAGE ABSOLUTE ERROR
12.5
12.0
11.5
11.0
10.5
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
LR
MAN
KL
CLIMATOLOGY
O RECORD SCORE
JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC

Fig. 24b

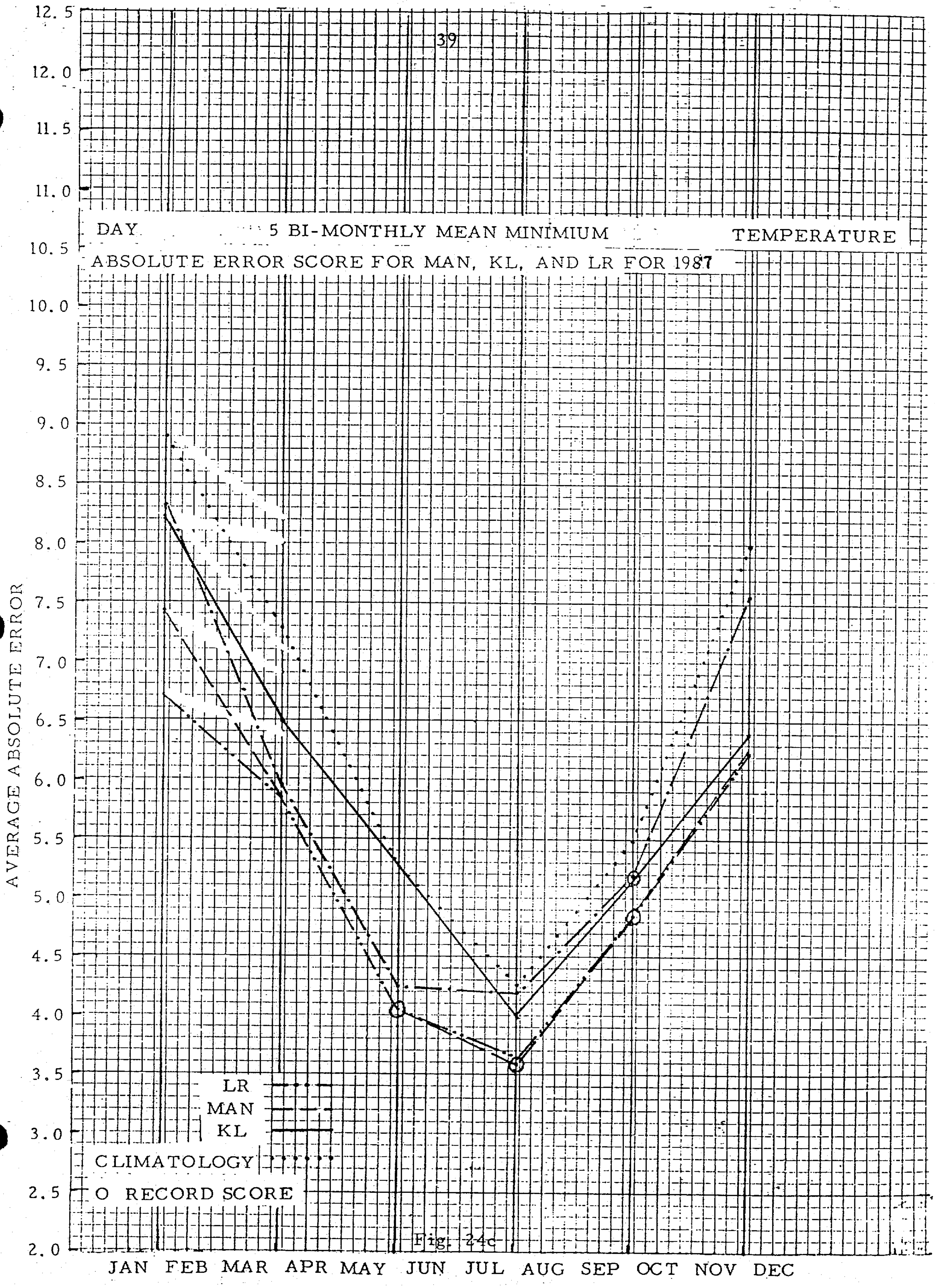

DAY 5 BI-MONTHLY MEAN MINIMIUM TEMPERATURE
ABSOLUTE ERROR SCORE FOR MAN, KL, AND LR FOR 1987
AVERAGE ABSOLUTE ERROR
12.5
12.0
11.5
11.0
10.5
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
LR
MAN
KL
CLIMATOLOGY
O RECORD SCORE
JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC

Fig. 24c

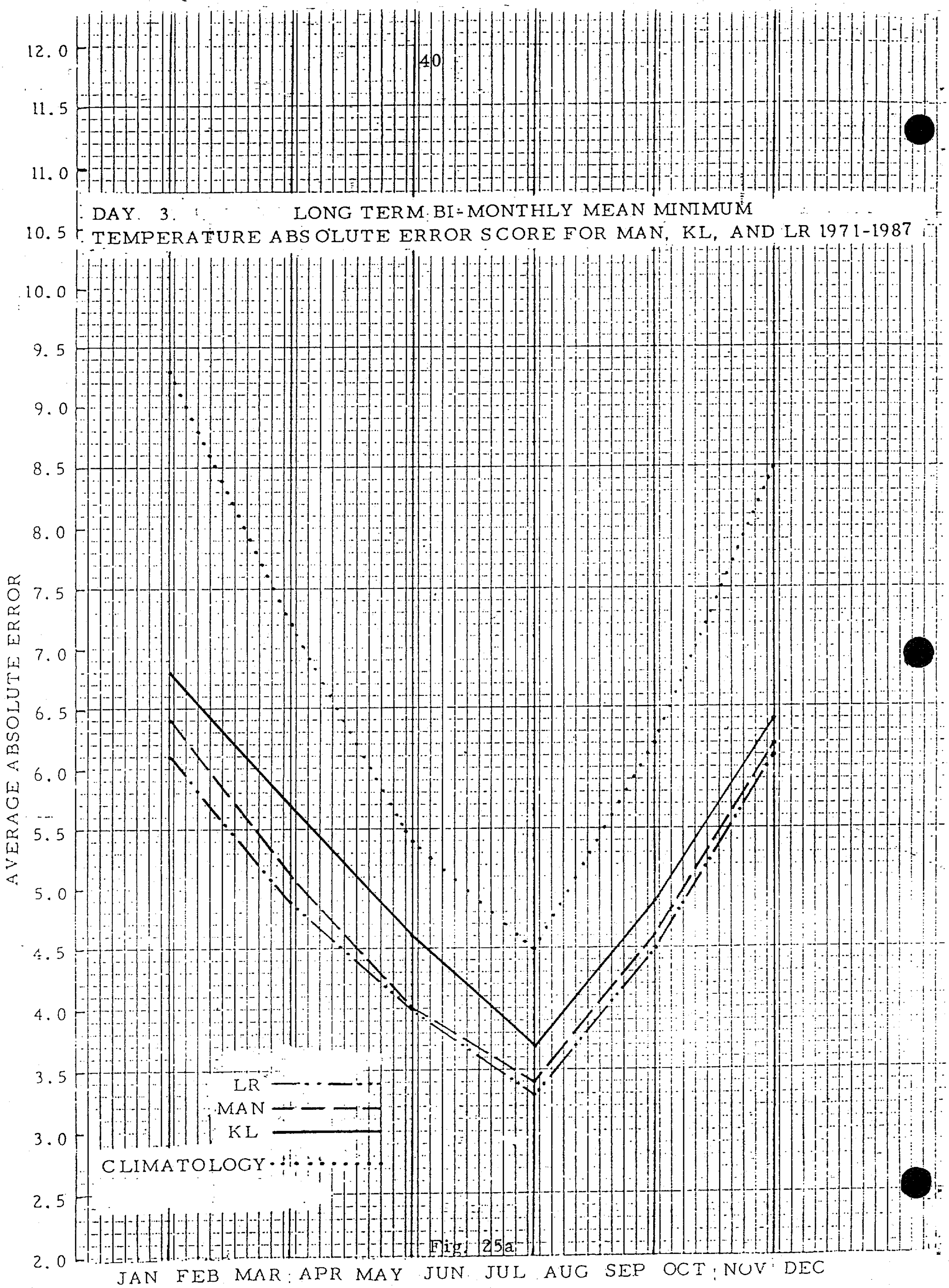

DAY 3. LONG TERM BI-MONTHLY MEAN MINIMUM TEMPERATURE ABSOLUTE ERROR SCORE FOR MAN, KL, AND LR 1971-1987
AVERAGE ABSOLUTE ERROR
12.0
11.5
11.0
10.5
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
LR
MAN
KL
CLIMATOLOGY
JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC

Fig. 25a

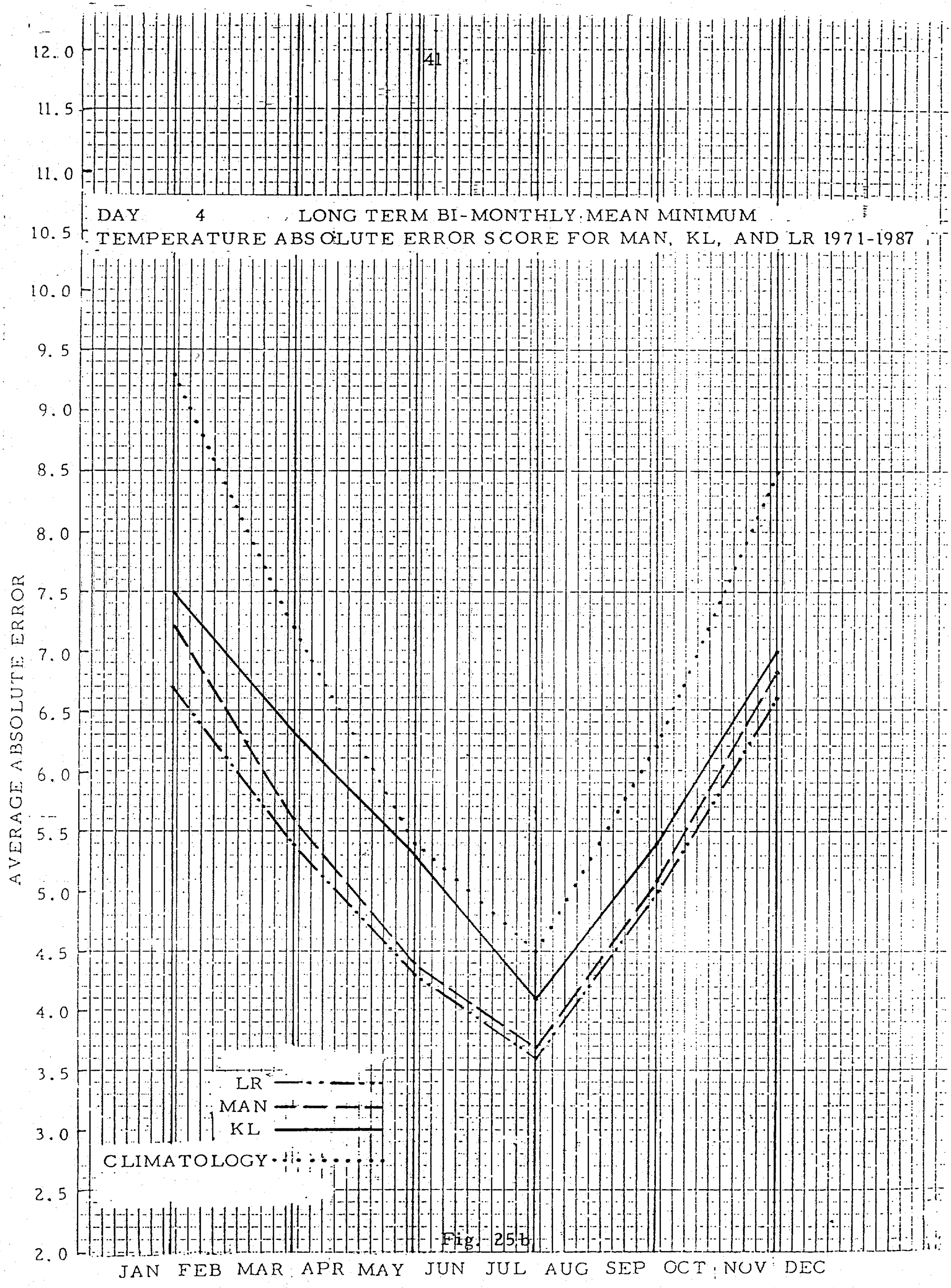

DAY 4 LONG TERM BI-MONTHLY MEAN MINIMUM
TEMPERATURE ABSOLUTE ERROR SCORE FOR MAN, KL, AND LR 1971-1987
AVERAGE ABSOLUTE ERROR
12.0
11.5
11.0
10.5
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
LR
MAN
KL
CLIMATOLOGY
JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC

Fig. 25b

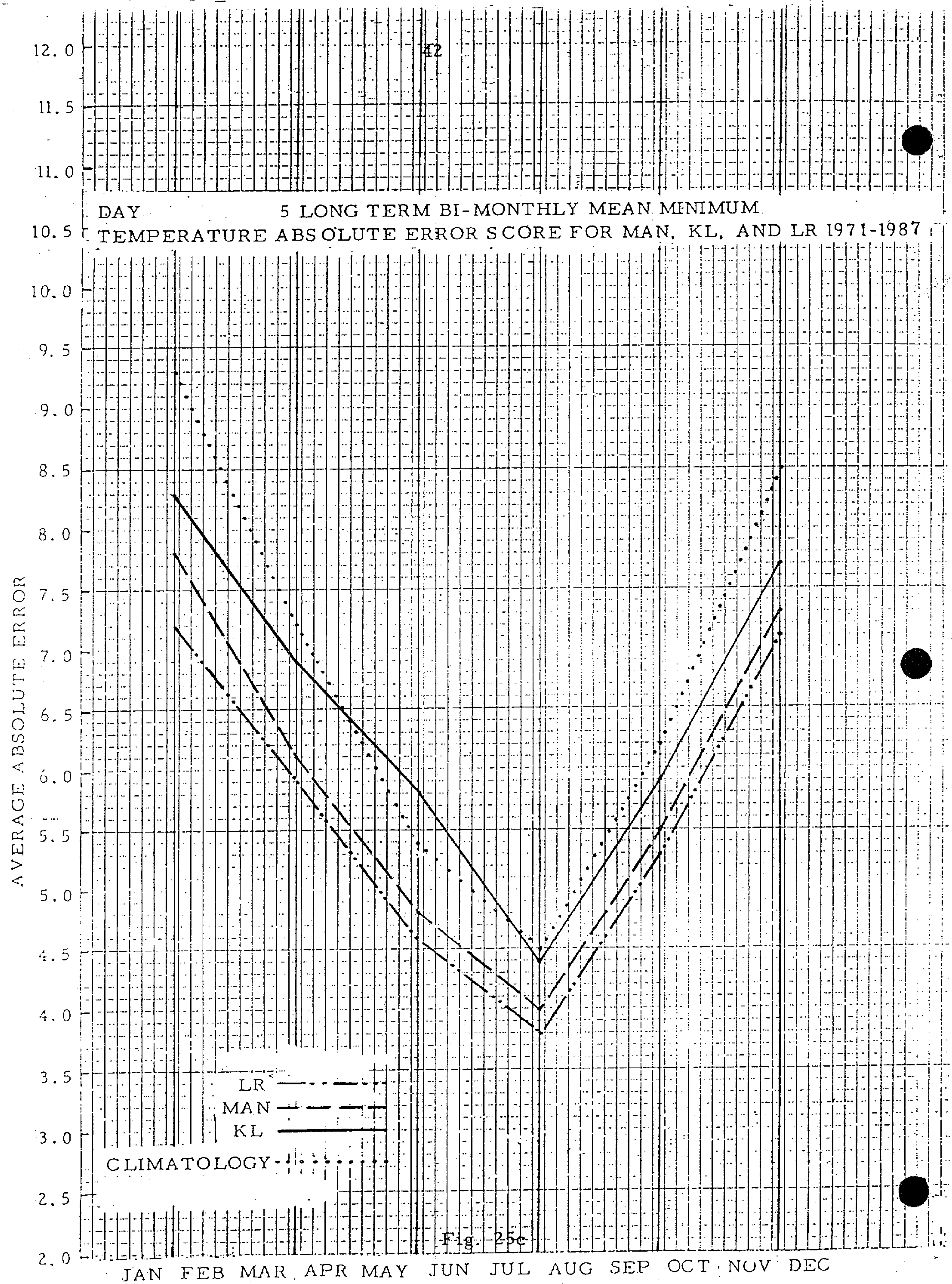

DAY 5 LONG TERM BI-MONTHLY MEAN MINIMUM
TEMPERATURE ABSOLUTE ERROR SCORE FOR MAN, KL, AND LR 1971-1987
AVERAGE ABSOLUTE ERROR
12.0
11.5
11.0
10.5
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC
LR
MAN
KL
CLIMATOLOGY

Fig. 25c

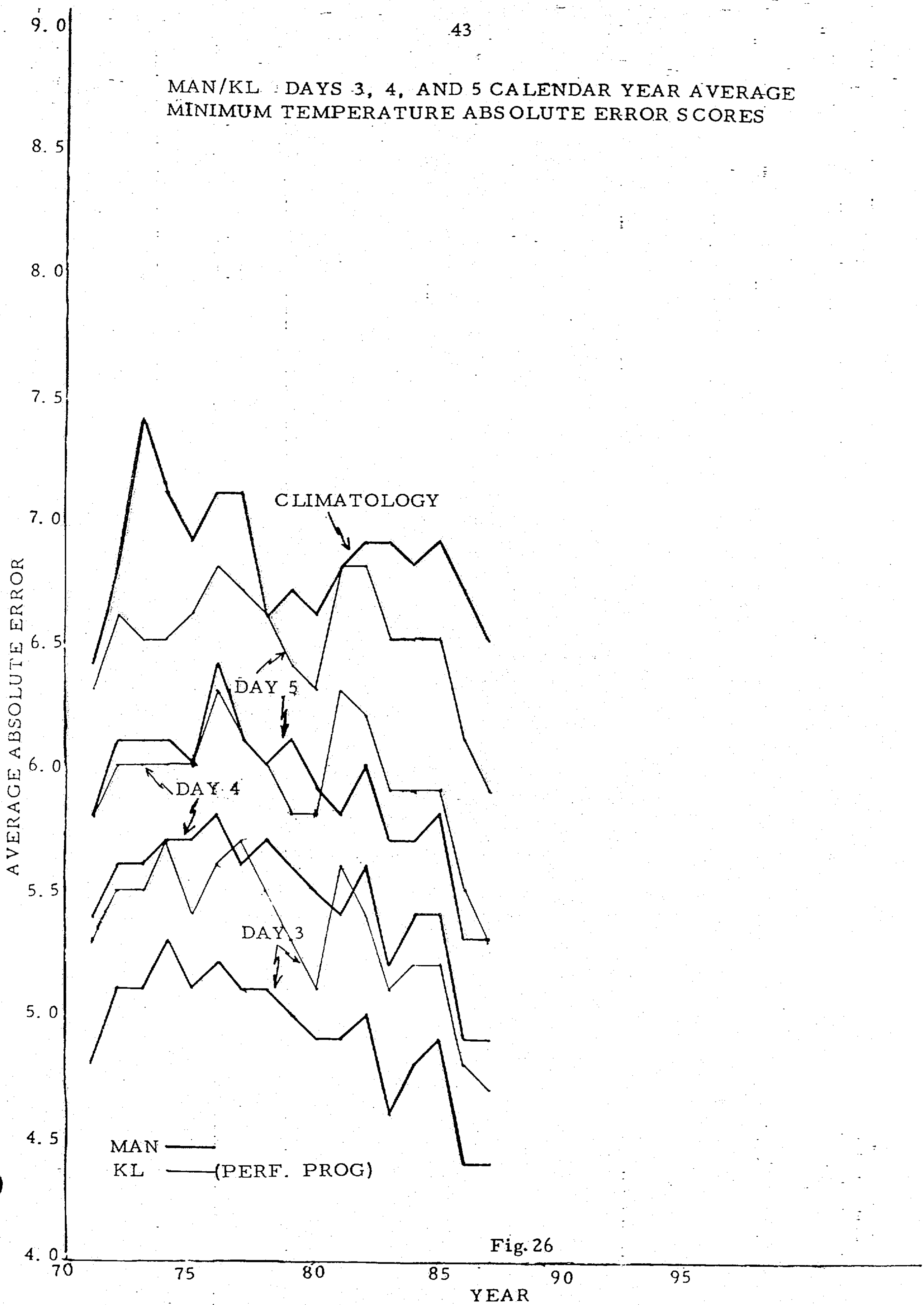

MAN/KL DAYS 3, 4, AND 5 CALENDAR YEAR AVERAGE MINIMUM TEMPERATURE ABSOLUTE ERROR SCORES
AVERAGE ABSOLUTE ERROR
9. 0
8. 5
8. 0
7. 5
7. 0
6. 5
6. 0
5. 5
5. 0
4. 5
4. 0
CLIMATOLOGY
DAY 5
DAY 4
DAY 3
MAN
KL (PERF. PROG)
70
75
80
85
90
95
YEAR

Fig. 26

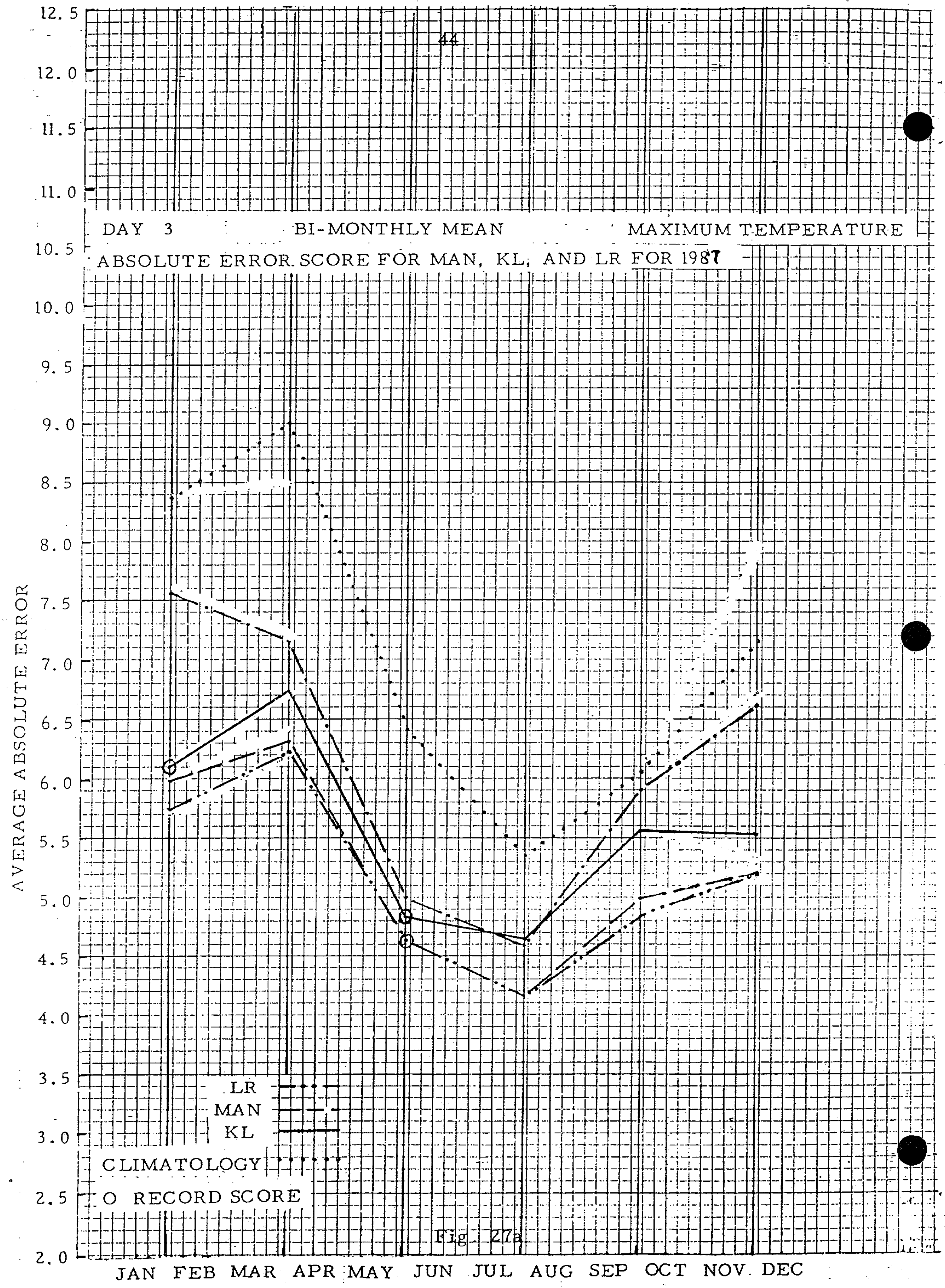

DAY 3
BI-MONTHLY MEAN
MAXIMUM TEMPERATURE
ABSOLUTE ERROR SCORE FOR MAN, KL, AND LR FOR 1987
AVERAGE ABSOLUTE ERROR
12.5
12.0
11.5
11.0
10.5
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
LR
MAN
KL
CLIMATOLOGY
O RECORD SCORE
JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC

Fig. 27a

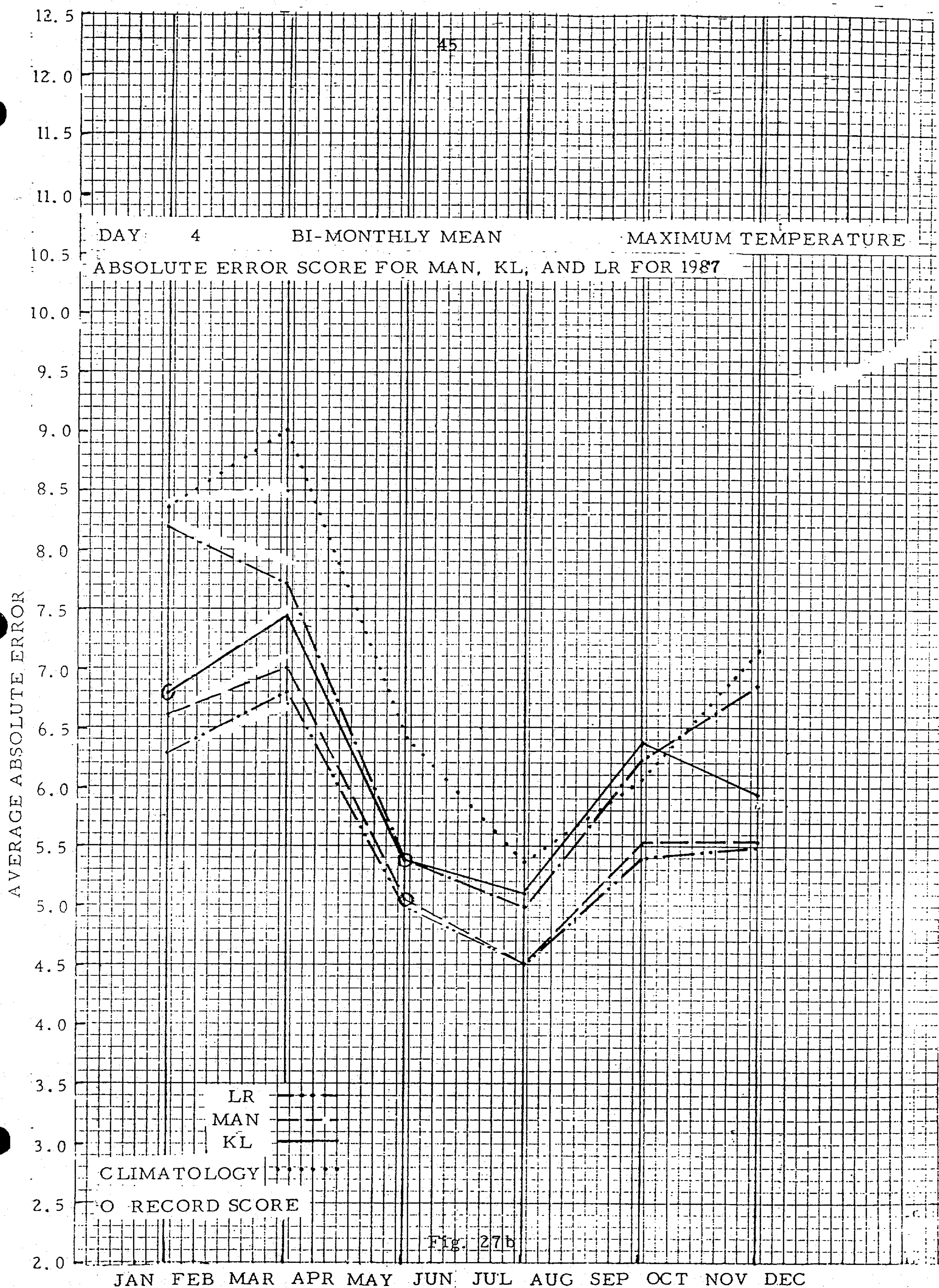

DAY 4 BI-MONTHLY MEAN MAXIMUM TEMPERATURE
ABSOLUTE ERROR SCORE FOR MAN, KL, AND LR FOR 1987
AVERAGE ABSOLUTE ERROR
12.5
12.0
11.5
11.0
10.5
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
LR
MAN
KL
CLIMATOLOGY
O RECORD SCORE
JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC

Fig. 27b

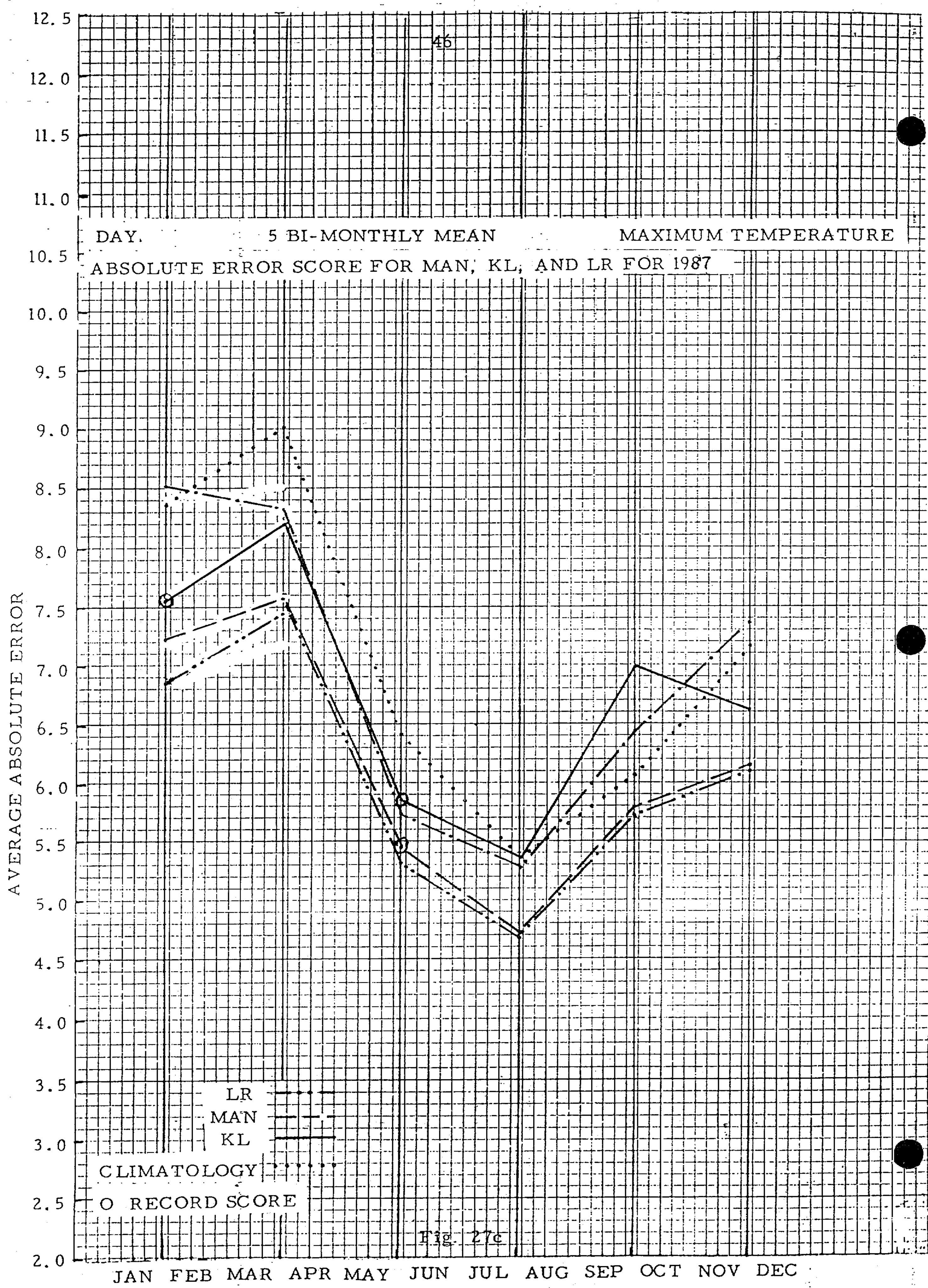

DAY. 5 BI-MONTHLY MEAN MAXIMUM TEMPERATURE
ABSOLUTE ERROR SCORE FOR MAN, KL, AND LR FOR 1987
AVERAGE ABSOLUTE ERROR
12.5
12.0
11.5
11.0
10.5
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
LR
MAN
KL
CLIMATOLOGY
O RECORD SCORE
JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC

Fig. 27c

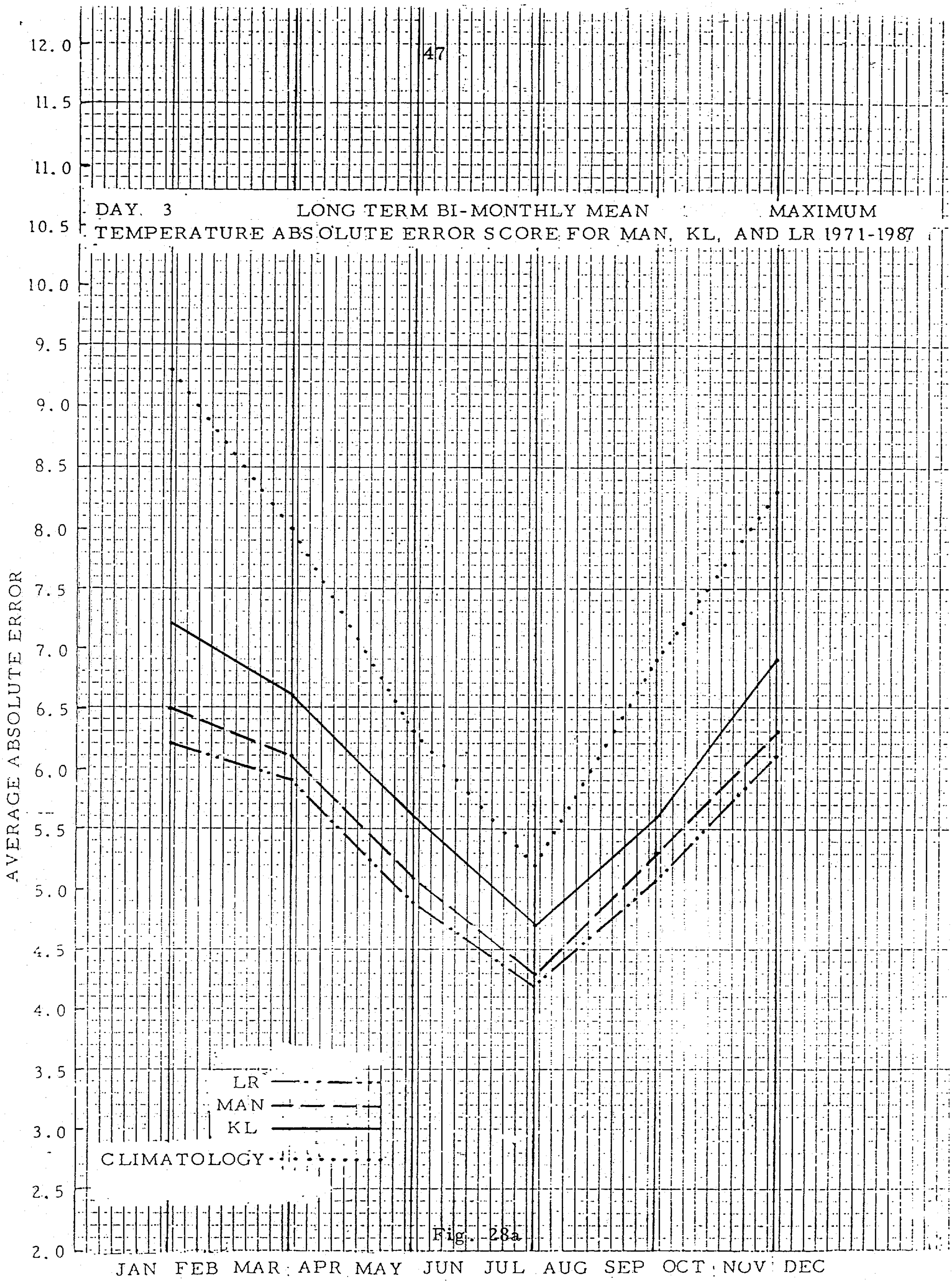

DAY 3 LONG TERM BI-MONTHLY MEAN MAXIMUM
TEMPERATURE ABSOLUTE ERROR SCORE FOR MAN, KL, AND LR 1971-1987
AVERAGE ABSOLUTE ERROR
12.0
11.5
11.0
10.5
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
LR
MAN
KL
CLIMATOLOGY
JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC

Fig. 28a

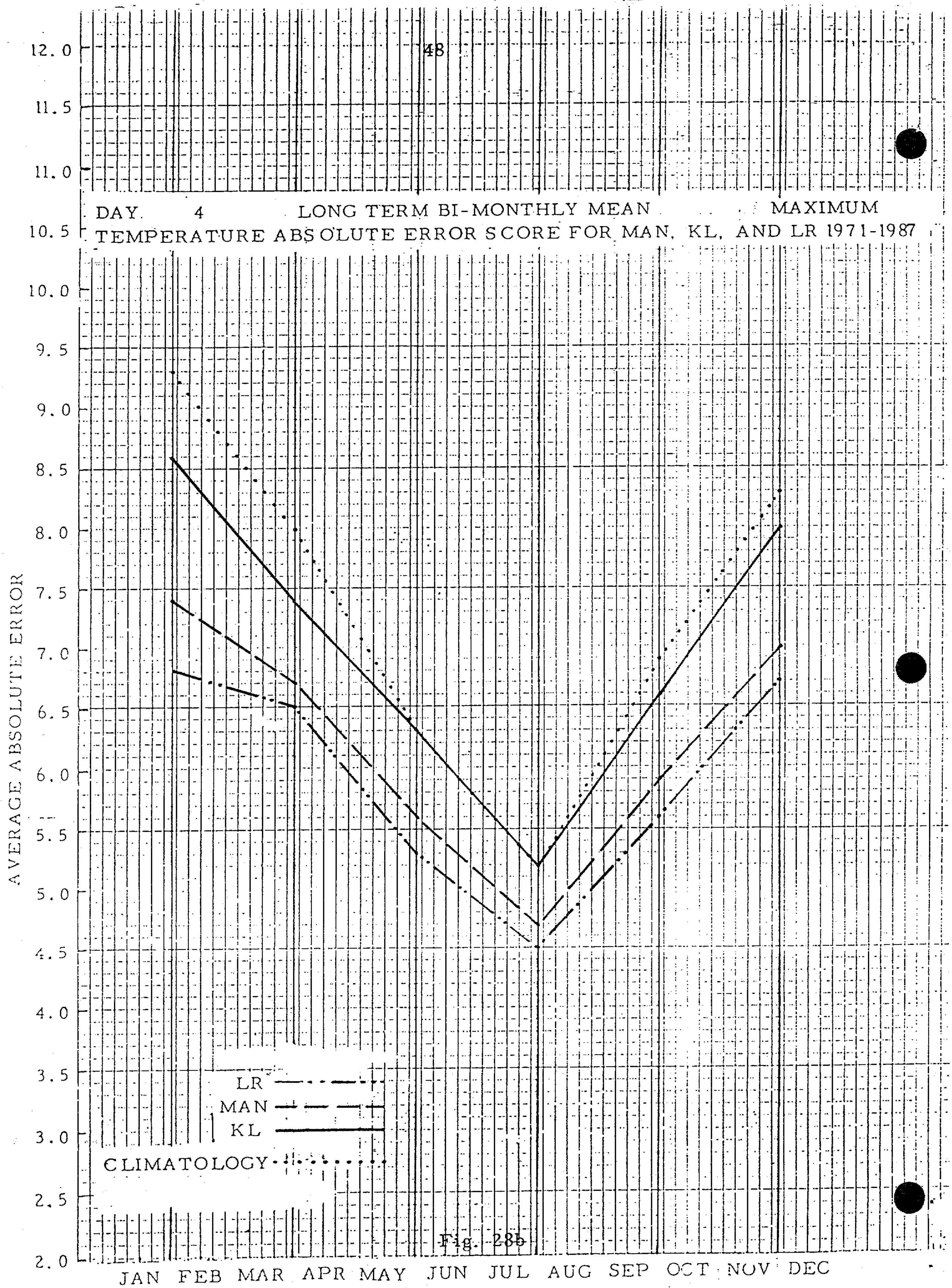

DAY 4 LONG TERM BI-MONTHLY MEAN MAXIMUM
TEMPERATURE ABSOLUTE ERROR SCORE FOR MAN, KL, AND LR 1971-1987
AVERAGE ABSOLUTE ERROR
12.0
11.5
11.0
10.5
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC
LR
MAN
KL
CLIMATOLOGY

Fig. 28b

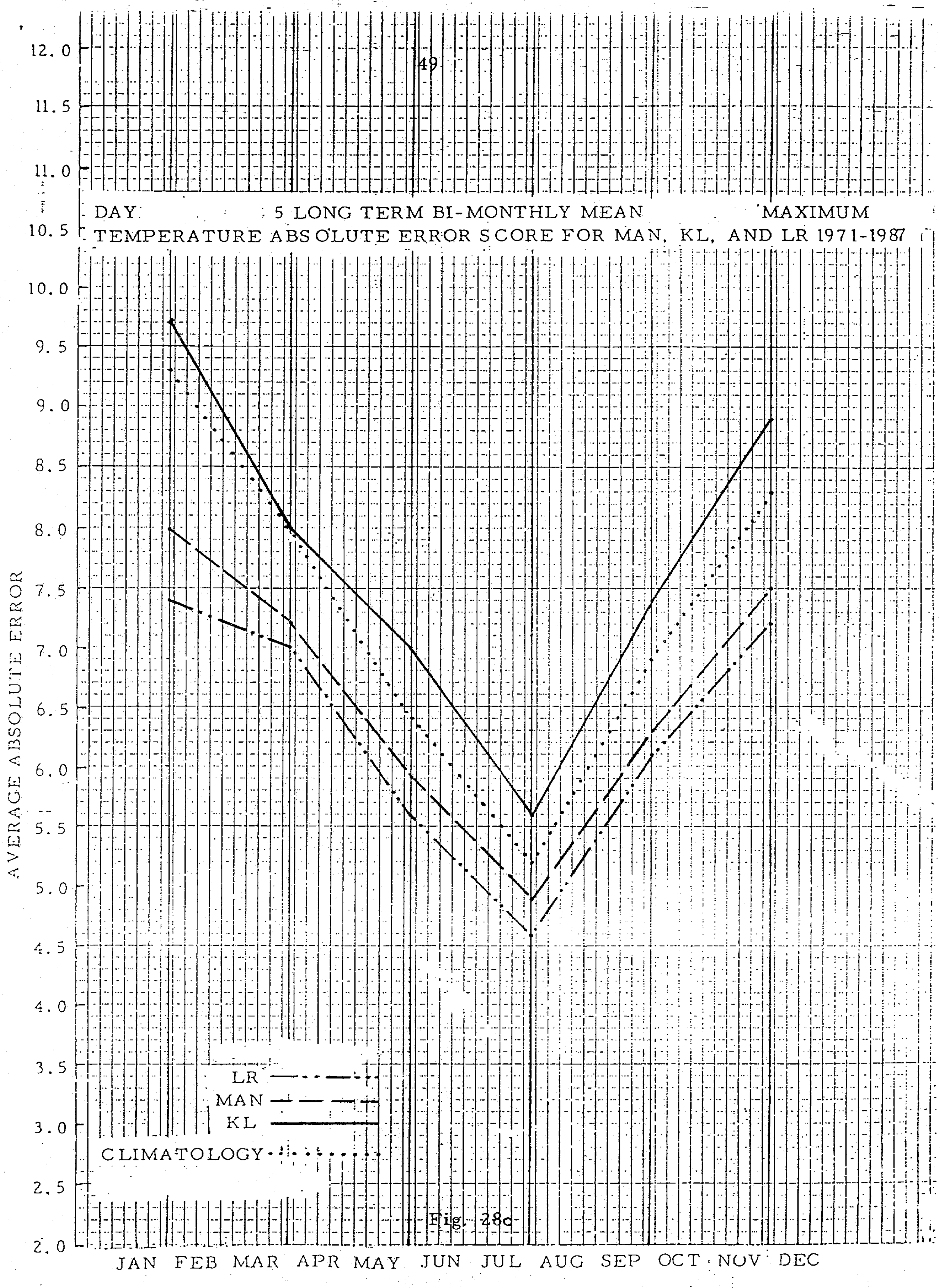

DAY 5 LONG TERM BI-MONTHLY MEAN MAXIMUM
TEMPERATURE ABSOLUTE ERROR SCORE FOR MAN, KL, AND LR 1971-1987
AVERAGE ABSOLUTE ERROR
12.0
11.5
11.0
10.5
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
LR
MAN
KL
CLIMATOLOGY
JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC

Fig. 28c

MAN/KL DAYS 3, 4, AND 5 CALENDAR YEAR AVERAGE MAXIMUM TEMPERATURE ABSOLUTE ERROR SCORES

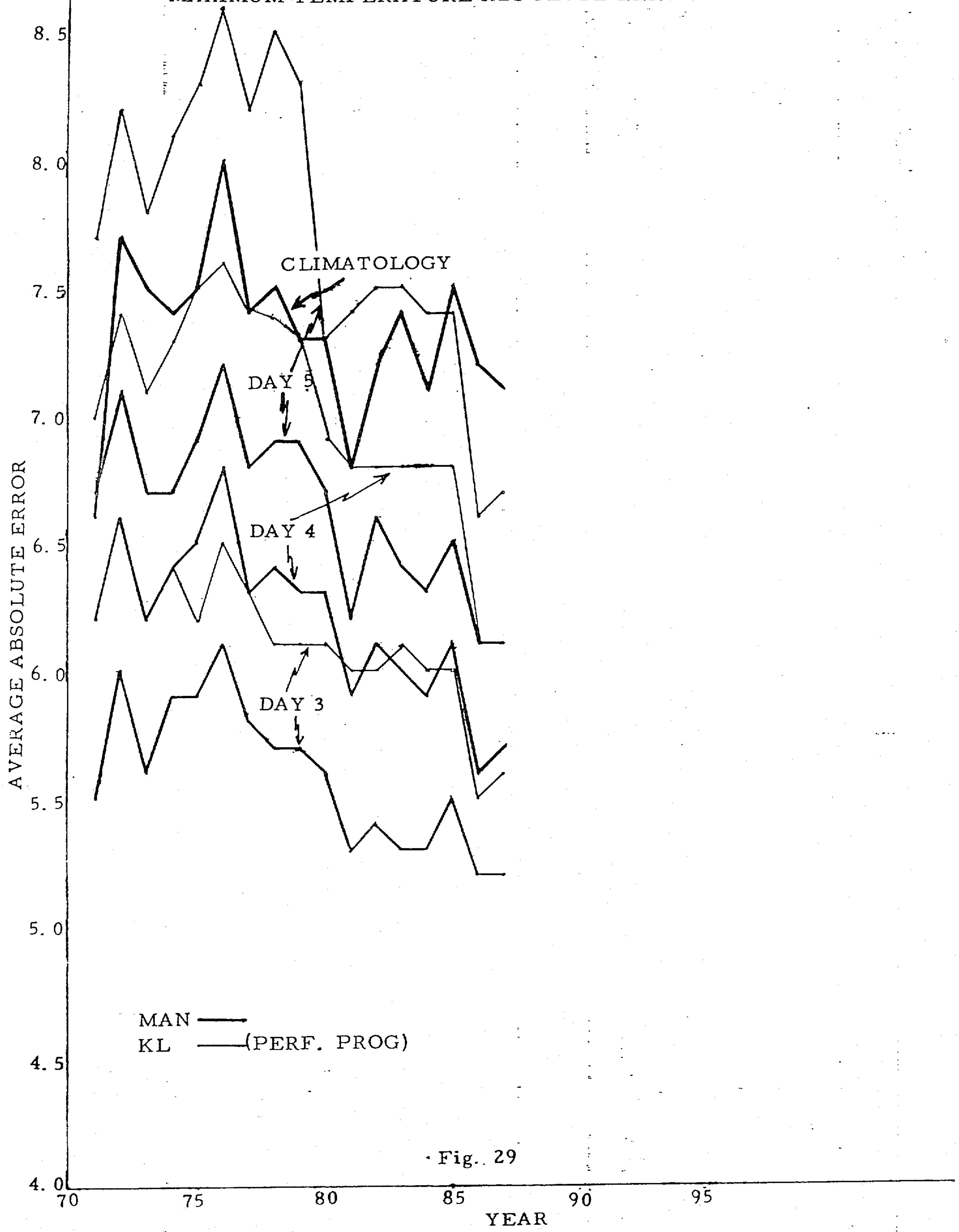


Fig. 29

OFFICIAL AND PERFECT PROG DAYS (3+4+5)/3
CALENDAR YEAR AVERAGE MAXIMUM/MINIMUM
TEMPERATURE ABSOLUTE ERROR SCORES

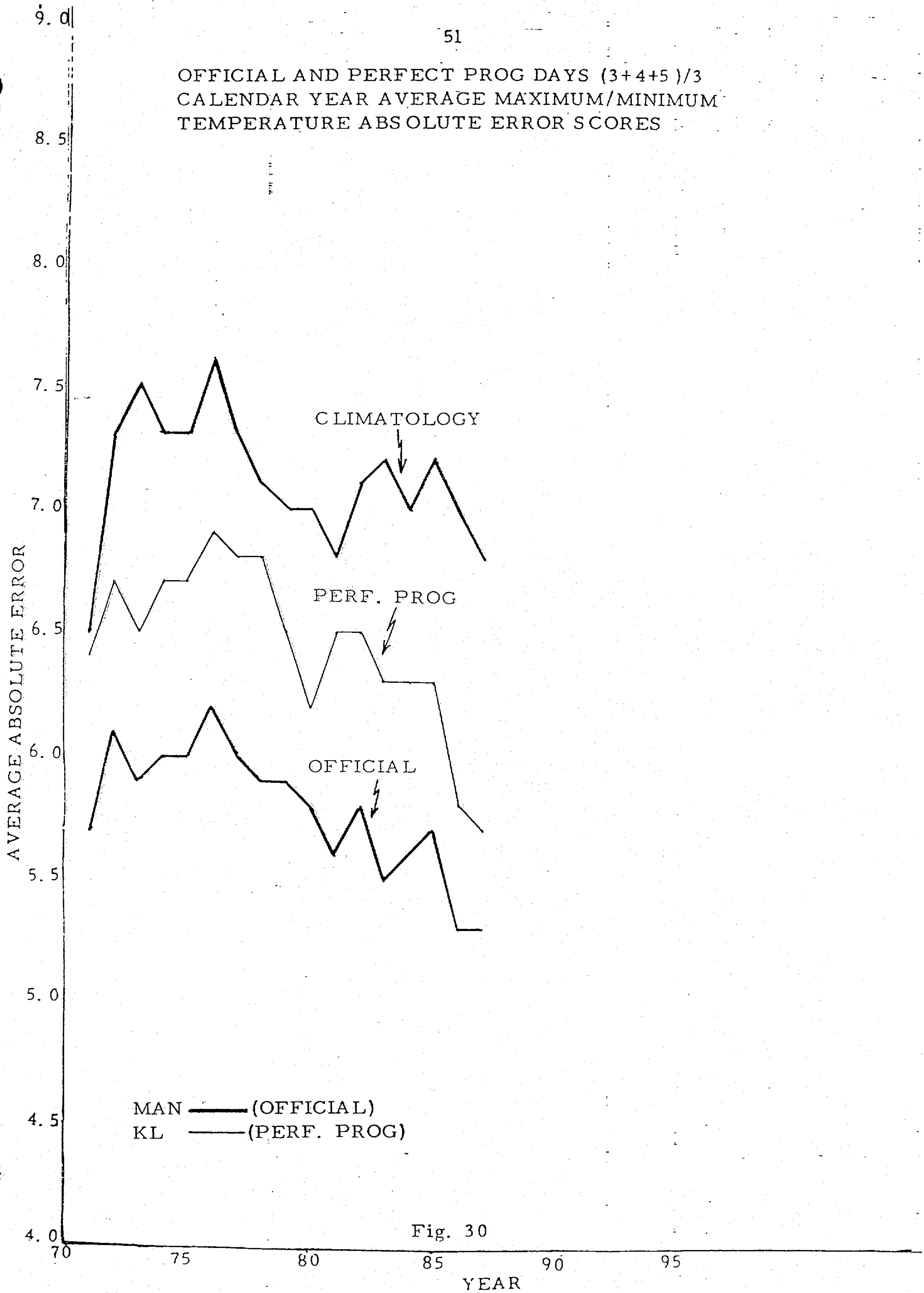


Fig. 30

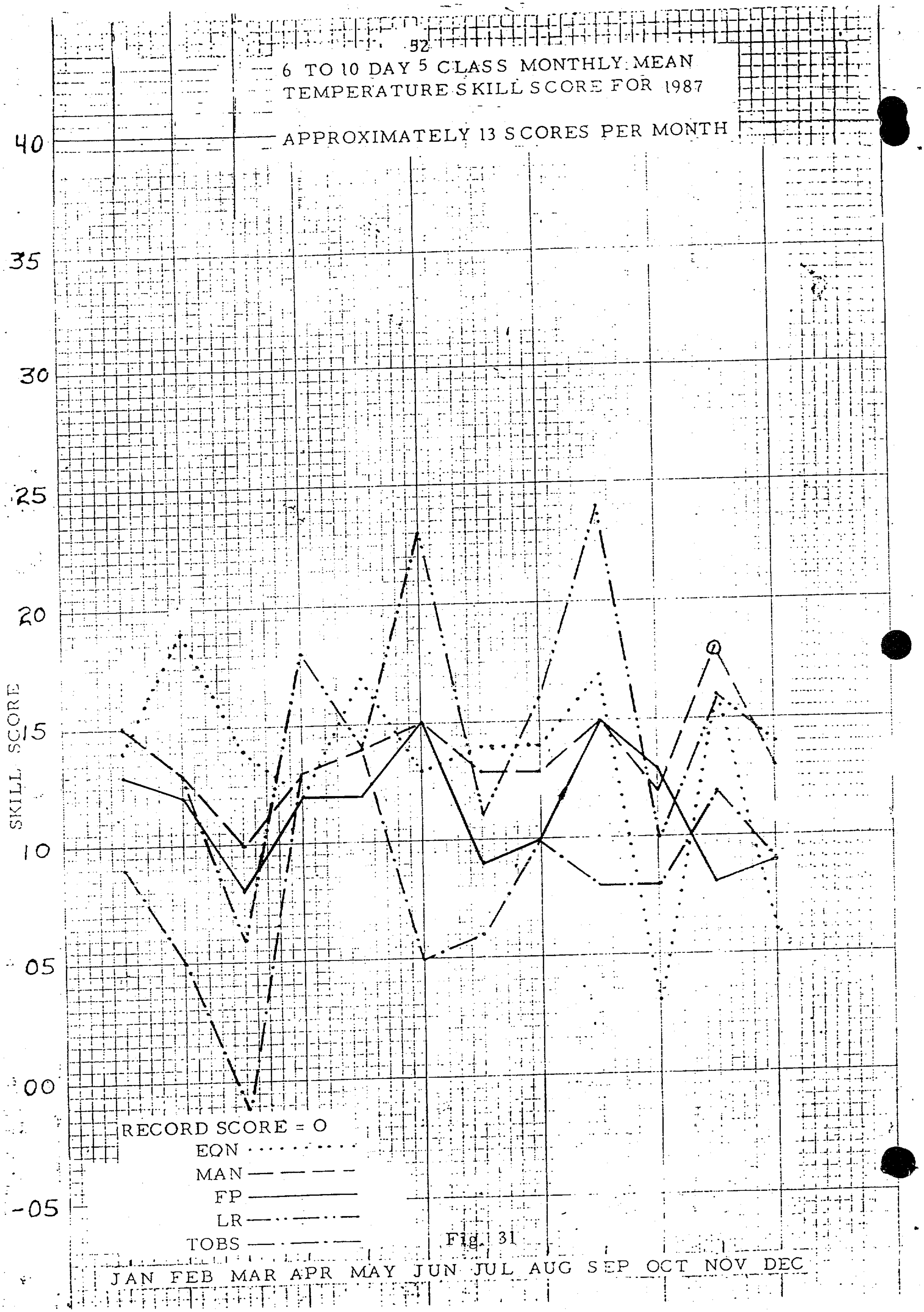

52
6 TO 10 DAY 5 CLASS MONTHLY MEAN
TEMPERATURE SKILL SCORE FOR 1987
APPROXIMATELY 13 SCORES PER MONTH
40
35
30
25
20
15
10
05
00
-05
SKILL SCORE
RECORD SCORE = O
EQN
MAN
FP
LR
TOBS
JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC

Fig. 31

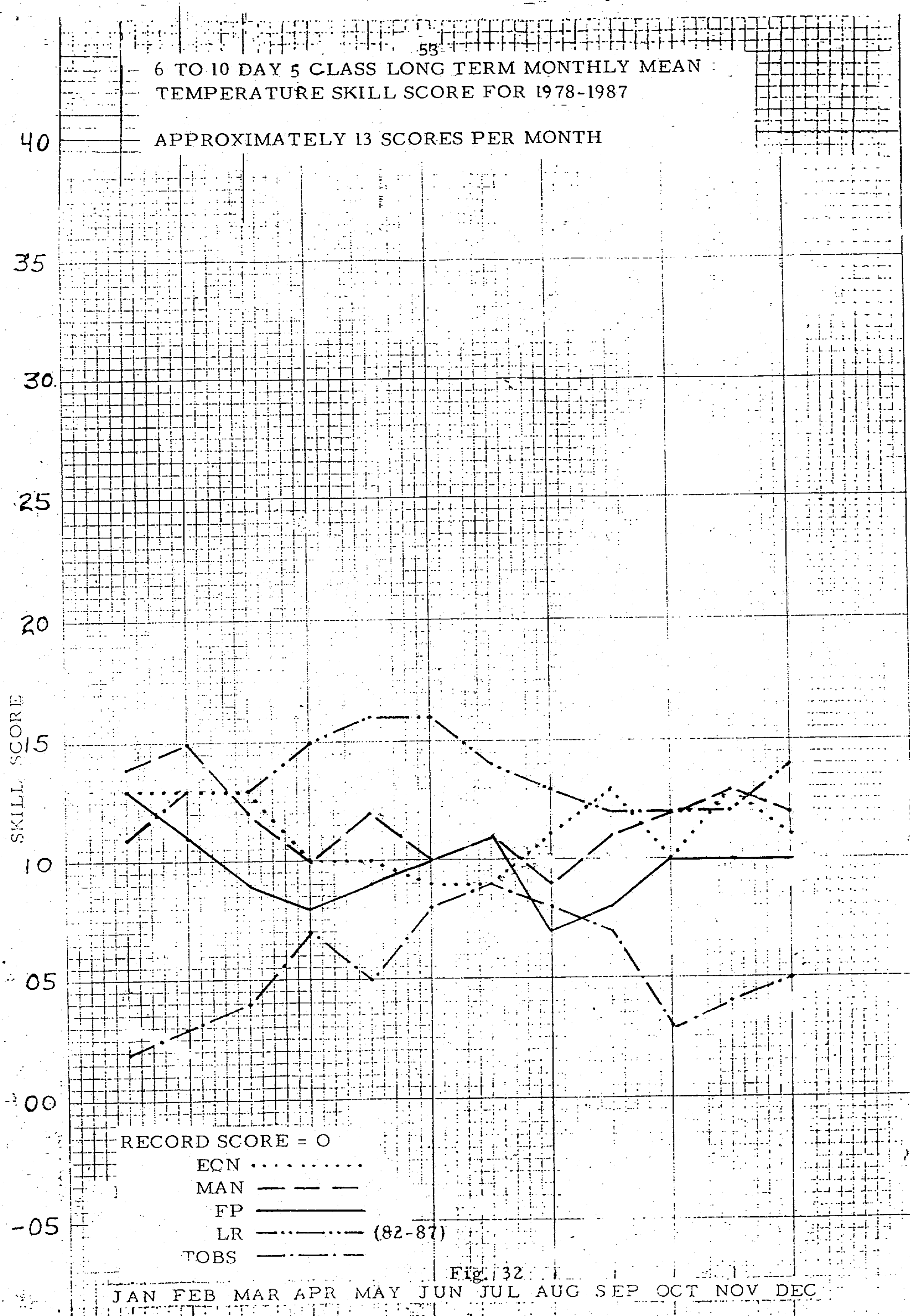

6 TO 10 DAY 5 CLASS LONG TERM MONTHLY MEAN
TEMPERATURE SKILL SCORE FOR 1978-1987
APPROXIMATELY 13 SCORES PER MONTH
40
35
30
25
20
15
10
05
00
-05
SKILL SCORE
RECORD SCORE = O
ECN
MAN
FP
LR (82-87)
TOBS
JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC

Fig. 32

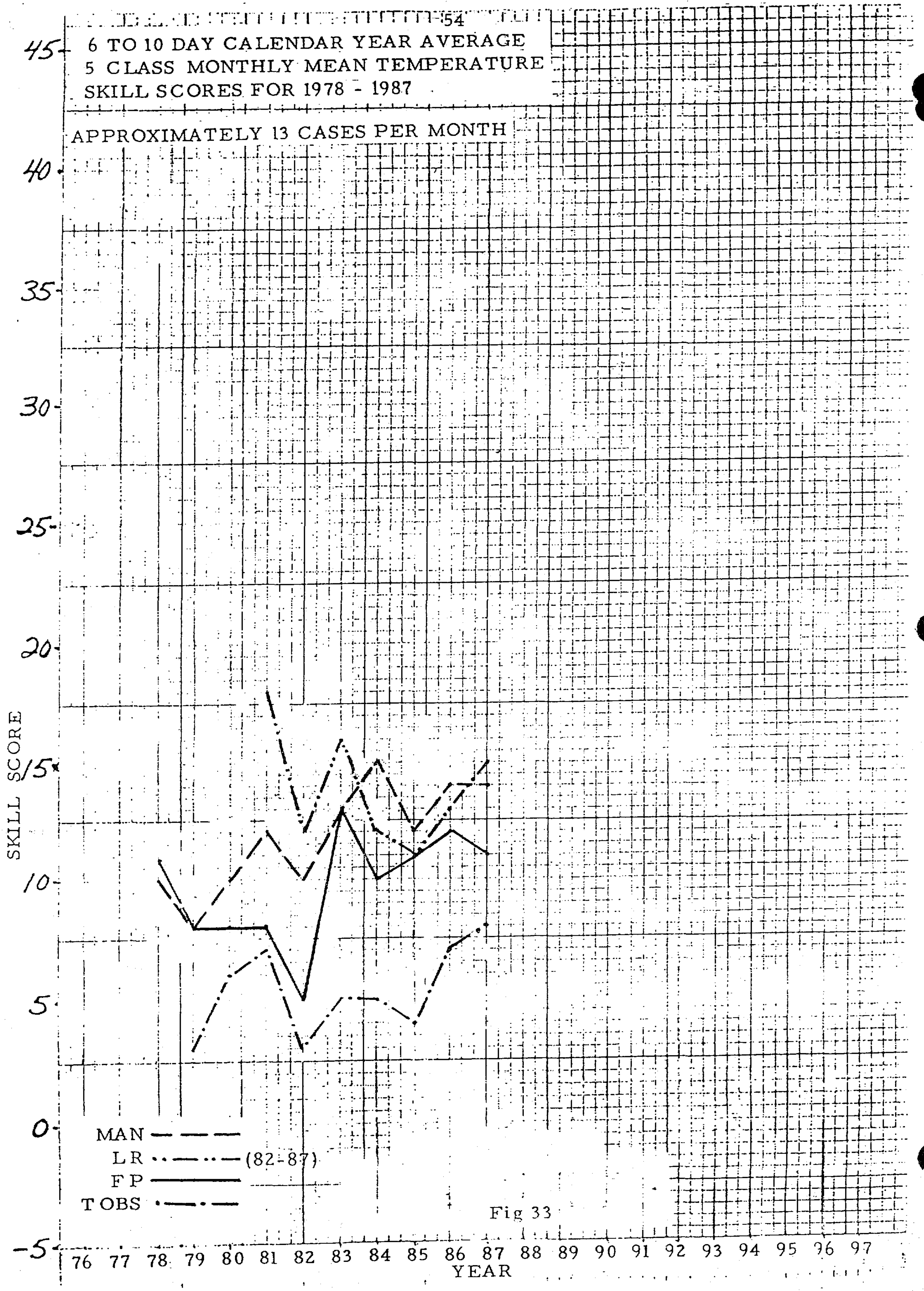

6 TO 10 DAY CALENDAR YEAR AVERAGE
5 CLASS MONTHLY MEAN TEMPERATURE
SKILL SCORES FOR 1978 - 1987
APPROXIMATELY 13 CASES PER MONTH
SKILL SCORE
45
40
35
30
25
20
15
10
5
0
-5
MAN
LR (82-87)
FP
T OBS
76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97
YEAR

Fig 33


6 TO 10 DAY 3 CLASS MONTHLY MEAN
TEMPERATURE SKILL SCORE FOR 1987
APPROXIMATELY 13 SCORES PER MONTH
40
35
30
25
20
15
10
05
00
-05
SKILL SCORE
RECORD SCORE = O
EQN
MAN
FP
LR
TOBS

Fig. 34

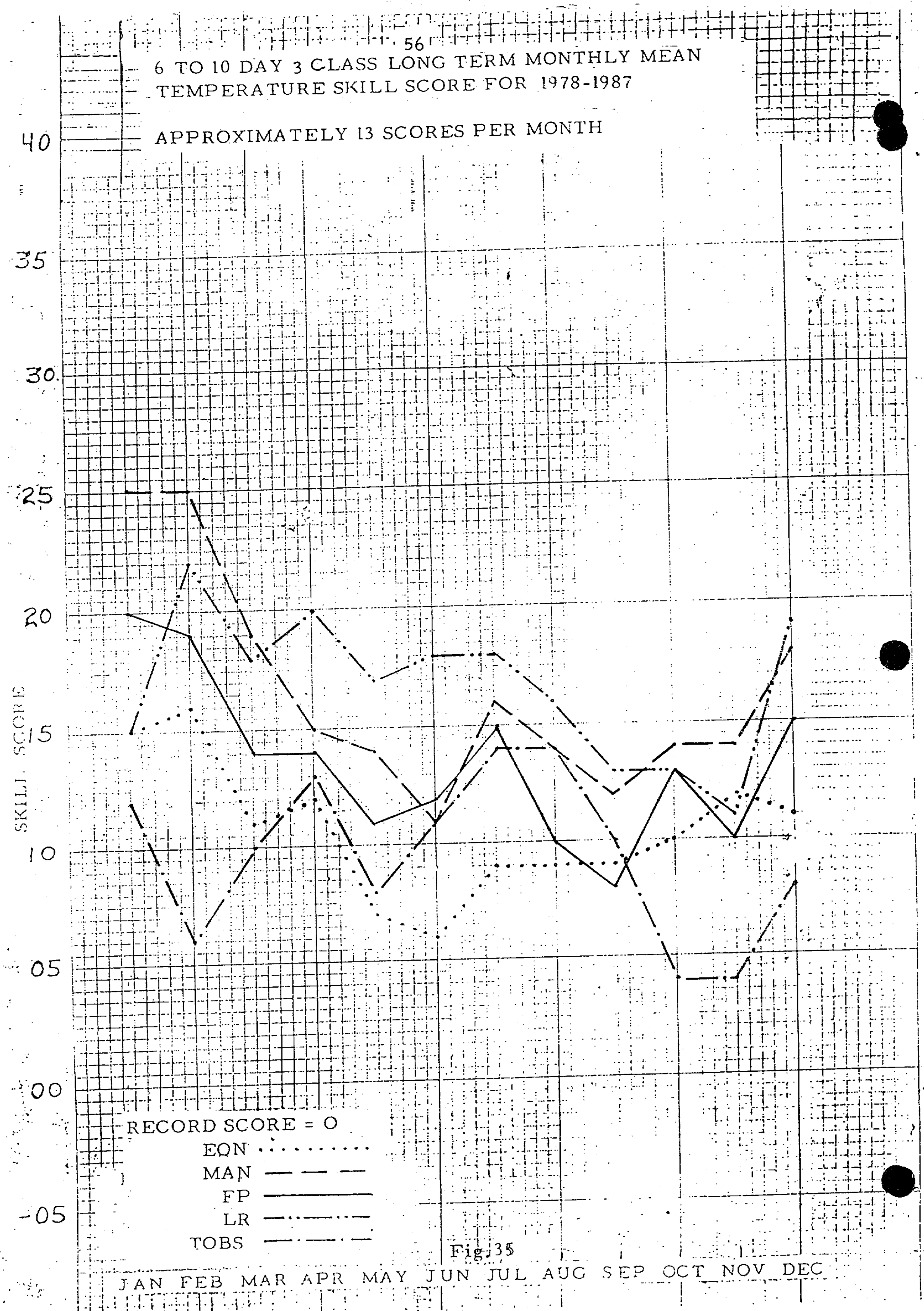

6 TO 10 DAY 3 CLASS LONG TERM MONTHLY MEAN
TEMPERATURE SKILL SCORE FOR 1978-1987
APPROXIMATELY 13 SCORES PER MONTH
SKILL SCORE
40
35
30
25
20
15
10
05
00
-05
RECORD SCORE = O
EQN
MAN
FP
LR
TOBS
JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC

Fig. 35

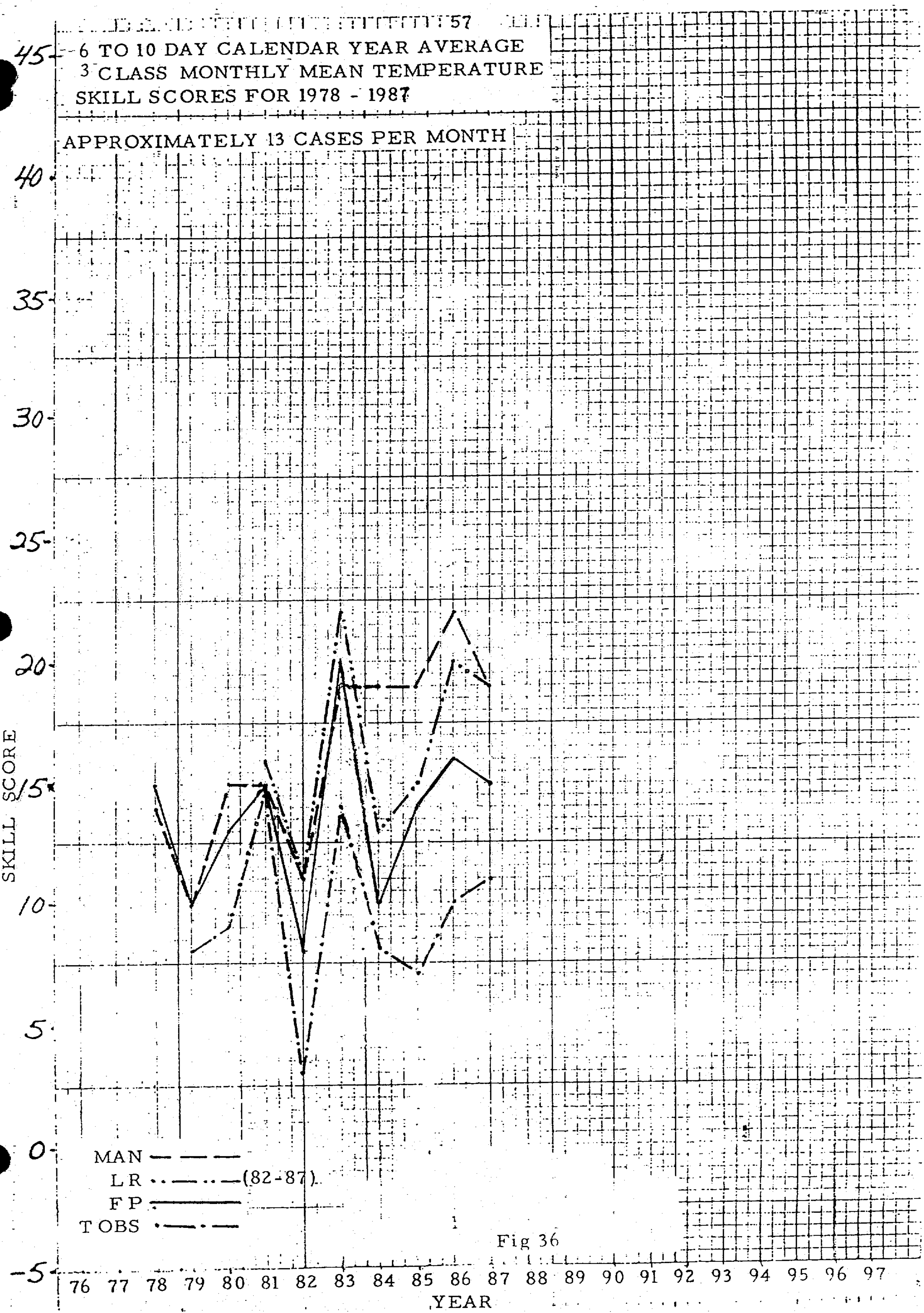

6 TO 10 DAY CALENDAR YEAR AVERAGE
3 CLASS MONTHLY MEAN TEMPERATURE
SKILL SCORES FOR 1978 - 1987
APPROXIMATELY 13 CASES PER MONTH
SKILL SCORE
45
40
35
30
25
20
15
10
5
0
-5
MAN
LR (82-87)
FP
T OBS
76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97
YEAR

Fig 36

SECTION 3

Man & Climatology

Precipitation Skill Scores

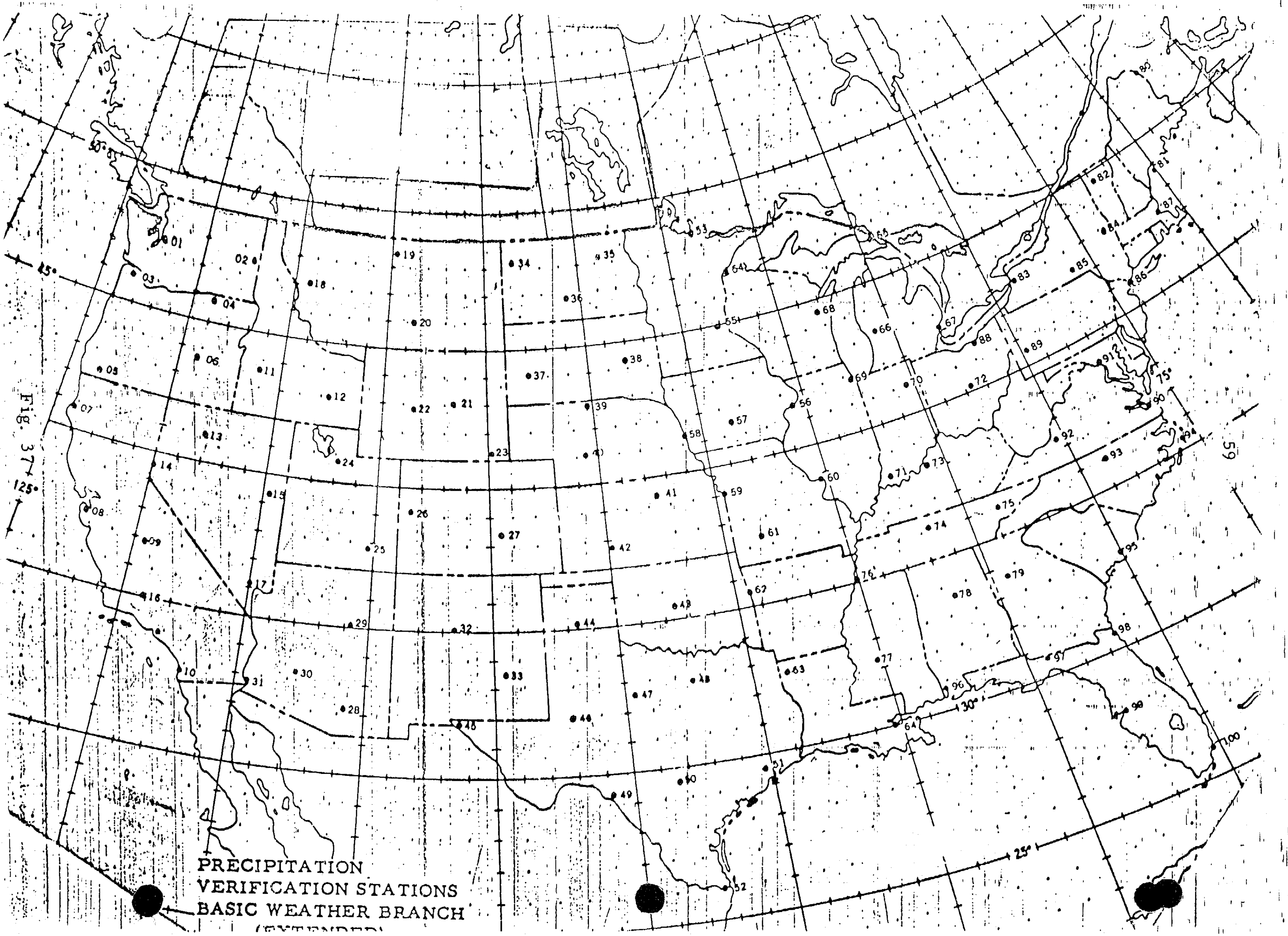

PRECIPITATION
VERIFICATION STATIONS
BASIC WEATHER BRANCH
(EXTENDED)

Fig. 37

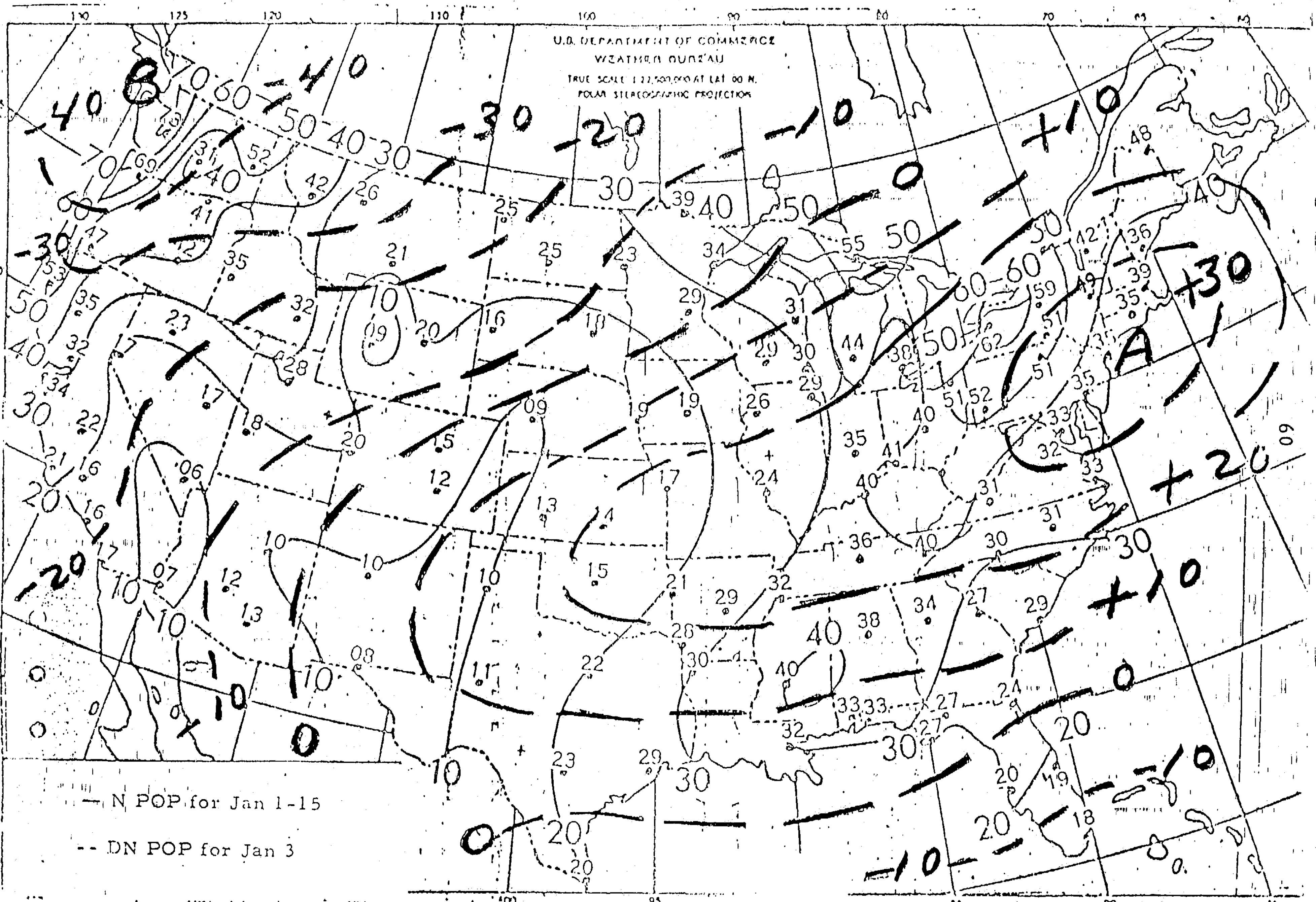

U.S. DEPARTMENT OF COMMERCE
WEATHER BUREAU
TRUE SCALE 1:22,500,000 AT LAT 60 N.
POLAR STEREOGRAPHIC PROJECTION
— N POP for Jan 1-15
-- DN POP for Jan 3

Fig. 38

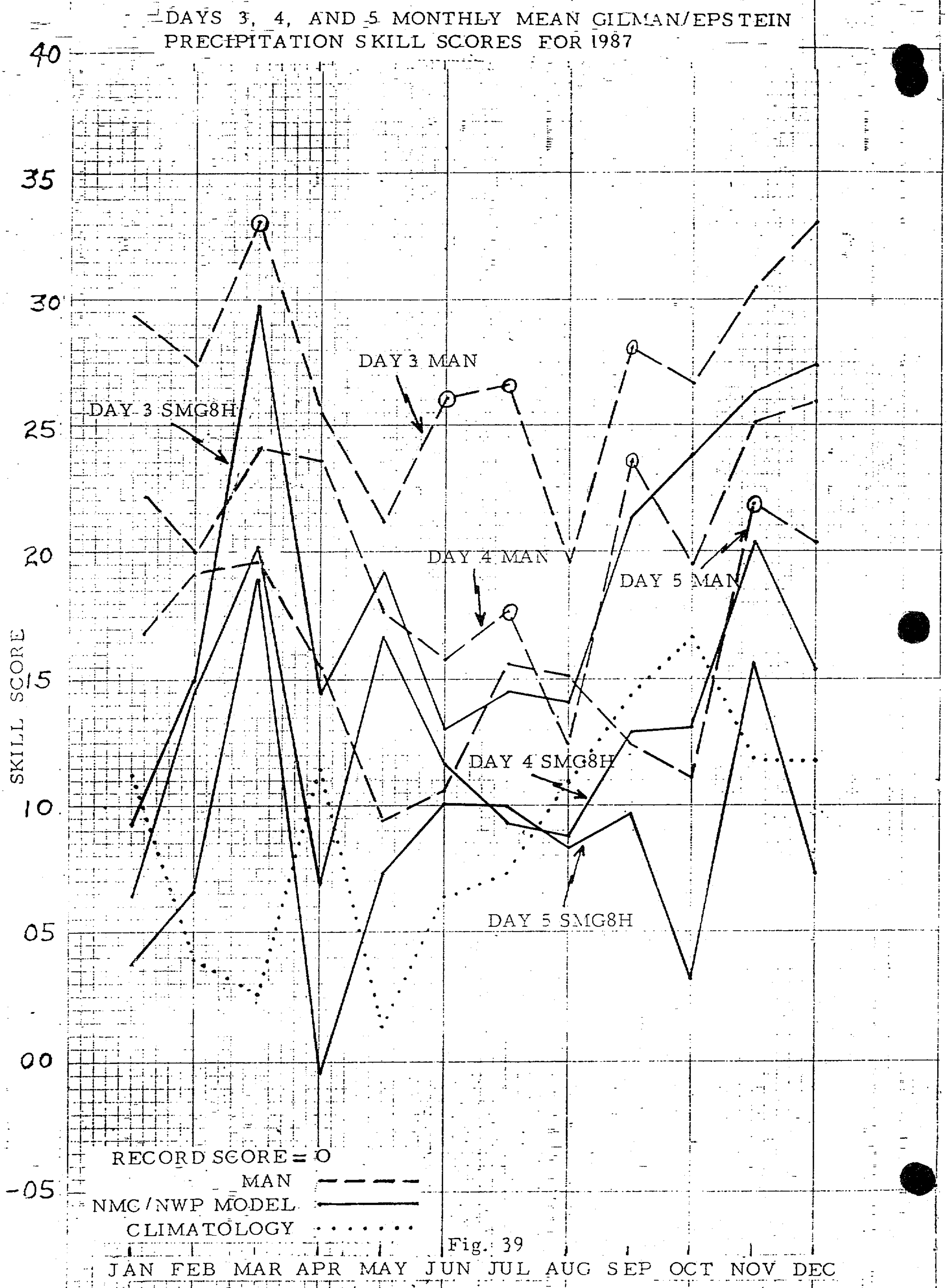

DAYS 3, 4, AND 5 MONTHLY MEAN GILMAN/EPSTEIN
PRECIPITATION SKILL SCORES FOR 1987
40
35
30
25
20
15
10
05
00
-05
SKILL SCORE
DAY 3 MAN
DAY 3 SMG8H
DAY 4 MAN
DAY 5 MAN
DAY 4 SMG8H
DAY 5 SMG8H
RECORD SCORE = O
MAN
NMC/NWP MODEL
CLIMATOLOGY
JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC

Fig. 39

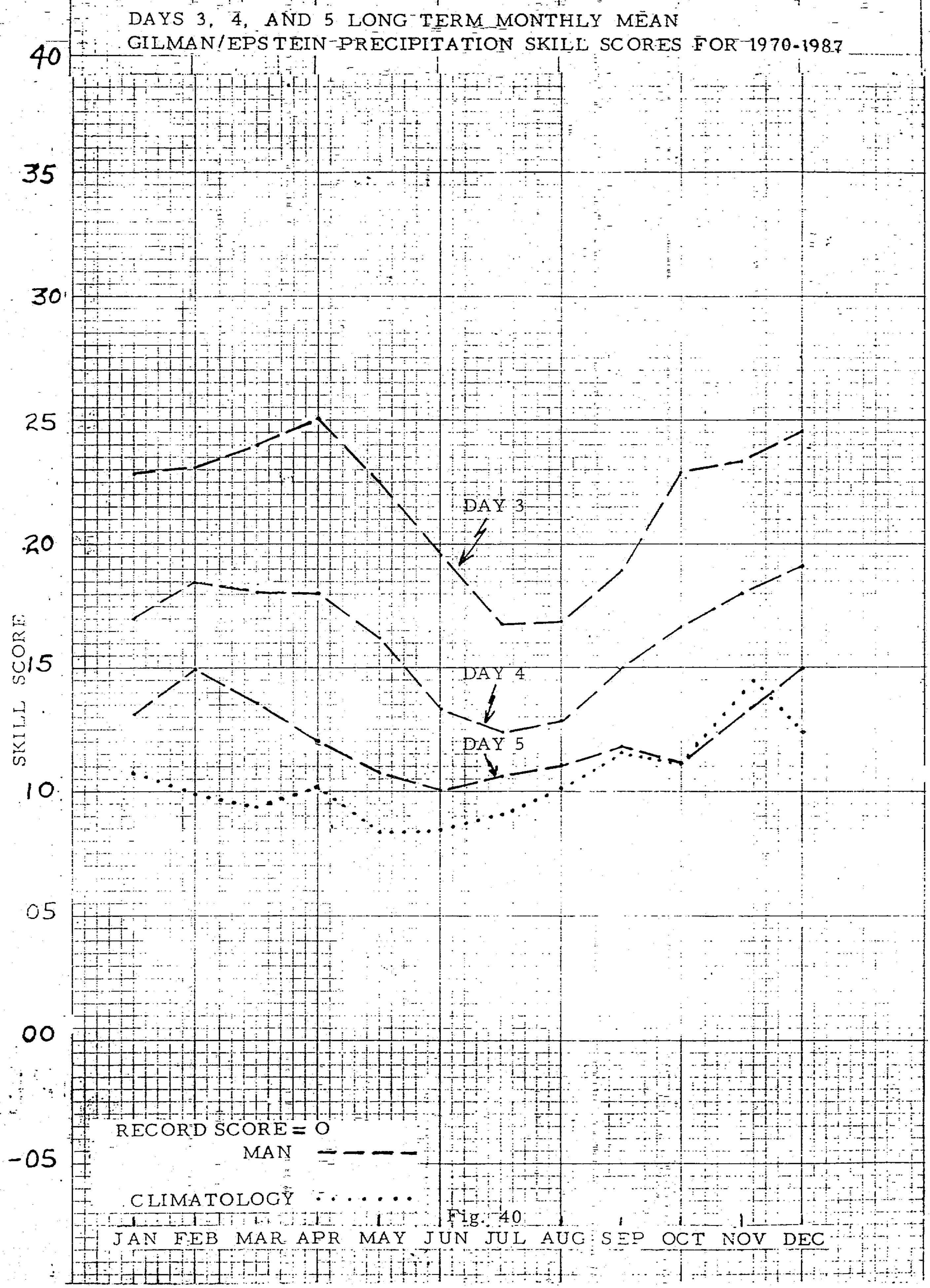

DAYS 3, 4, AND 5 LONG TERM MONTHLY MEAN
GILMAN/EPSTEIN PRECIPITATION SKILL SCORES FOR 1970-1987
40
35
30
25
20
15
10
05
00
-05
SKILL SCORE
DAY 3
DAY 4
DAY 5
RECORD SCORE = O
MAN
CLIMATOLOGY
JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC

Fig. 40

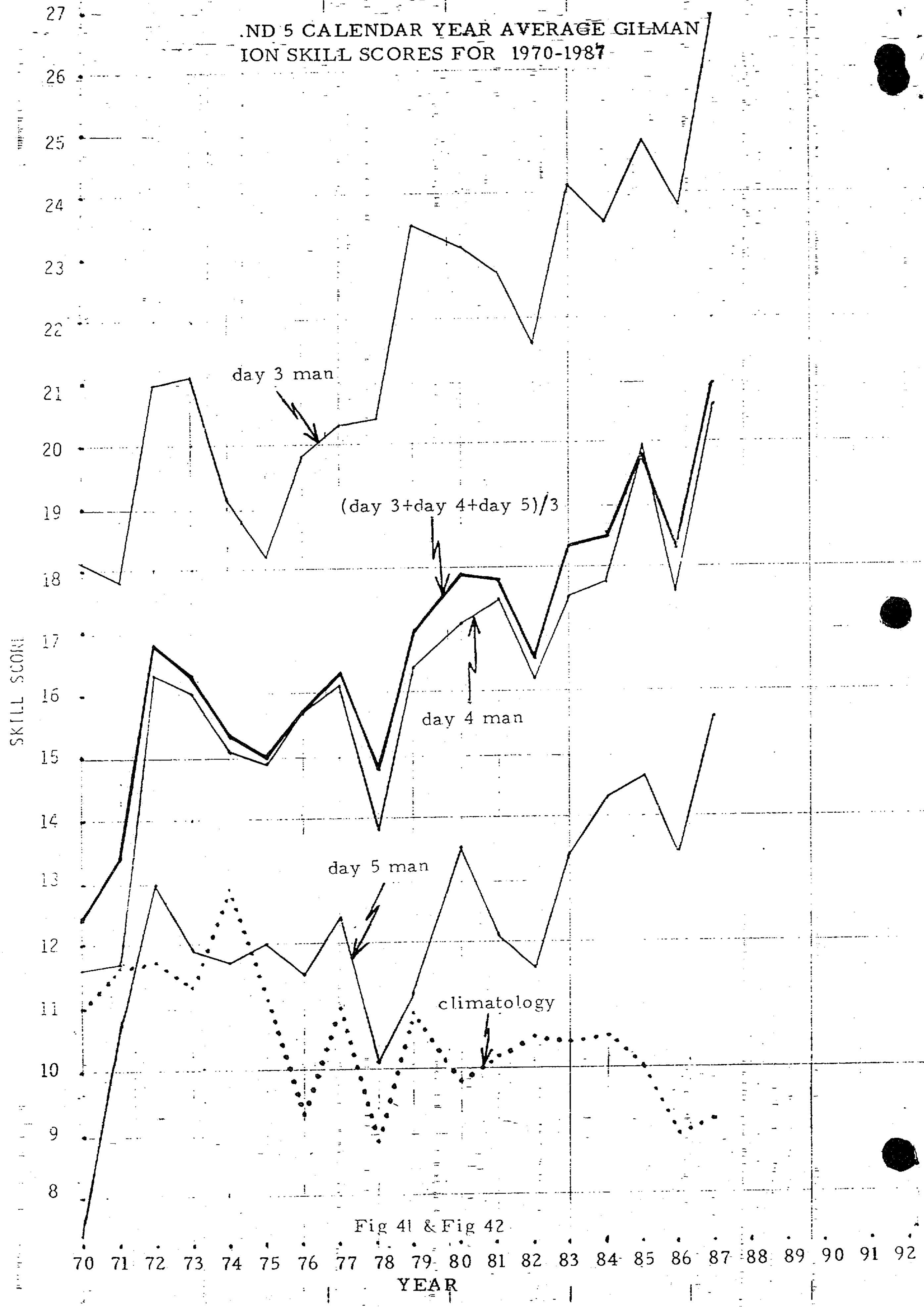

.ND 5 CALENDAR YEAR AVERAGE GILMAN
ION SKILL SCORES FOR 1970-1987
day 3 man
(day 3+day 4+day 5)/3
day 4 man
day 5 man
climatology
SKILL SCORE
YEAR

Fig 41 & Fig 42

DAYS 3, 4, AND 5 MONTHLY MEAN HUGHES PRECIPITATION SKILL SCORES FOR 1987

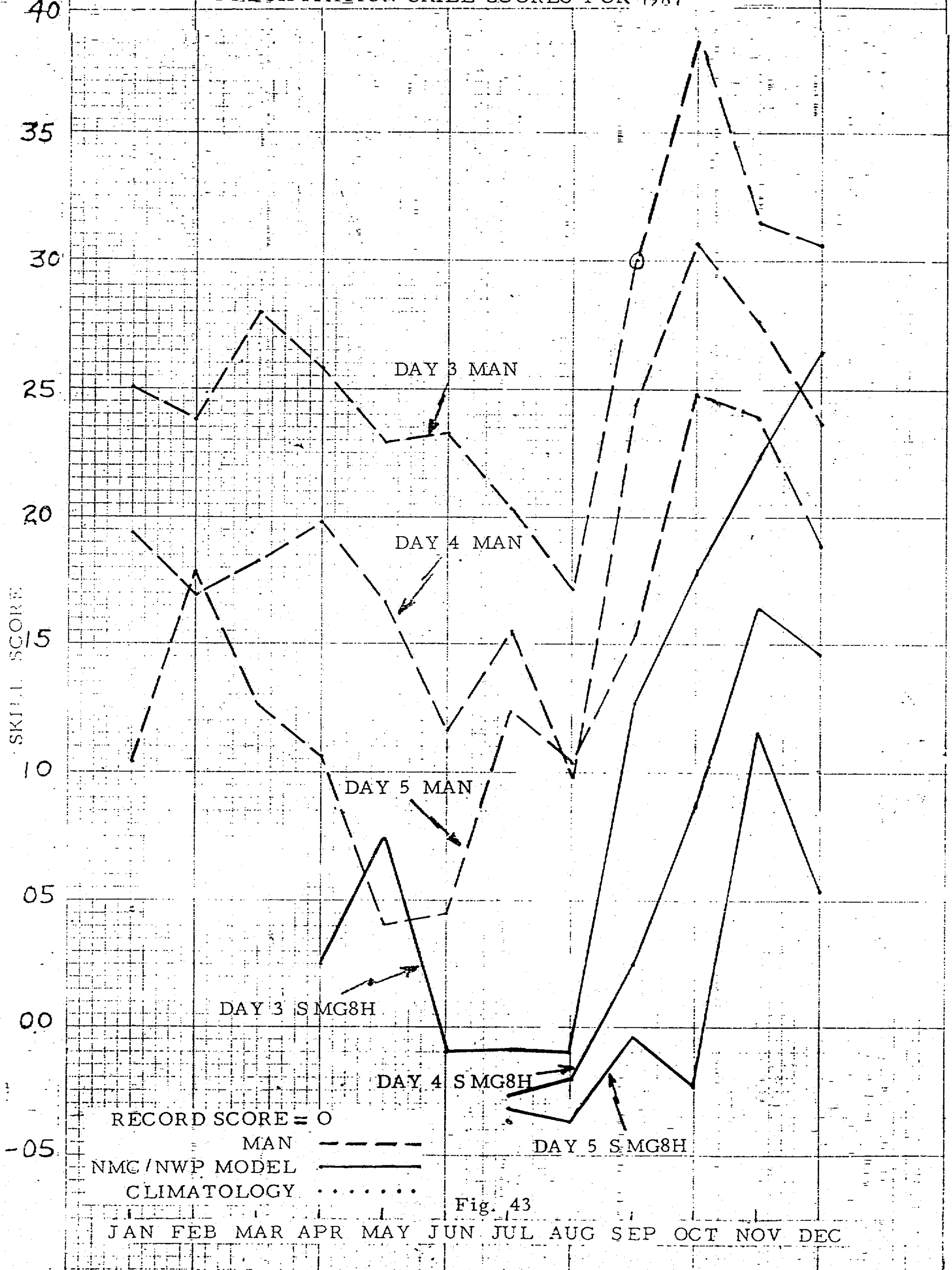


Fig. 43

DAYS-3, 4, AND 5 LONG TERM MONTHLY MEAN HUGHES PRECIPITATION SKILL SCORES FOR 1977-1987

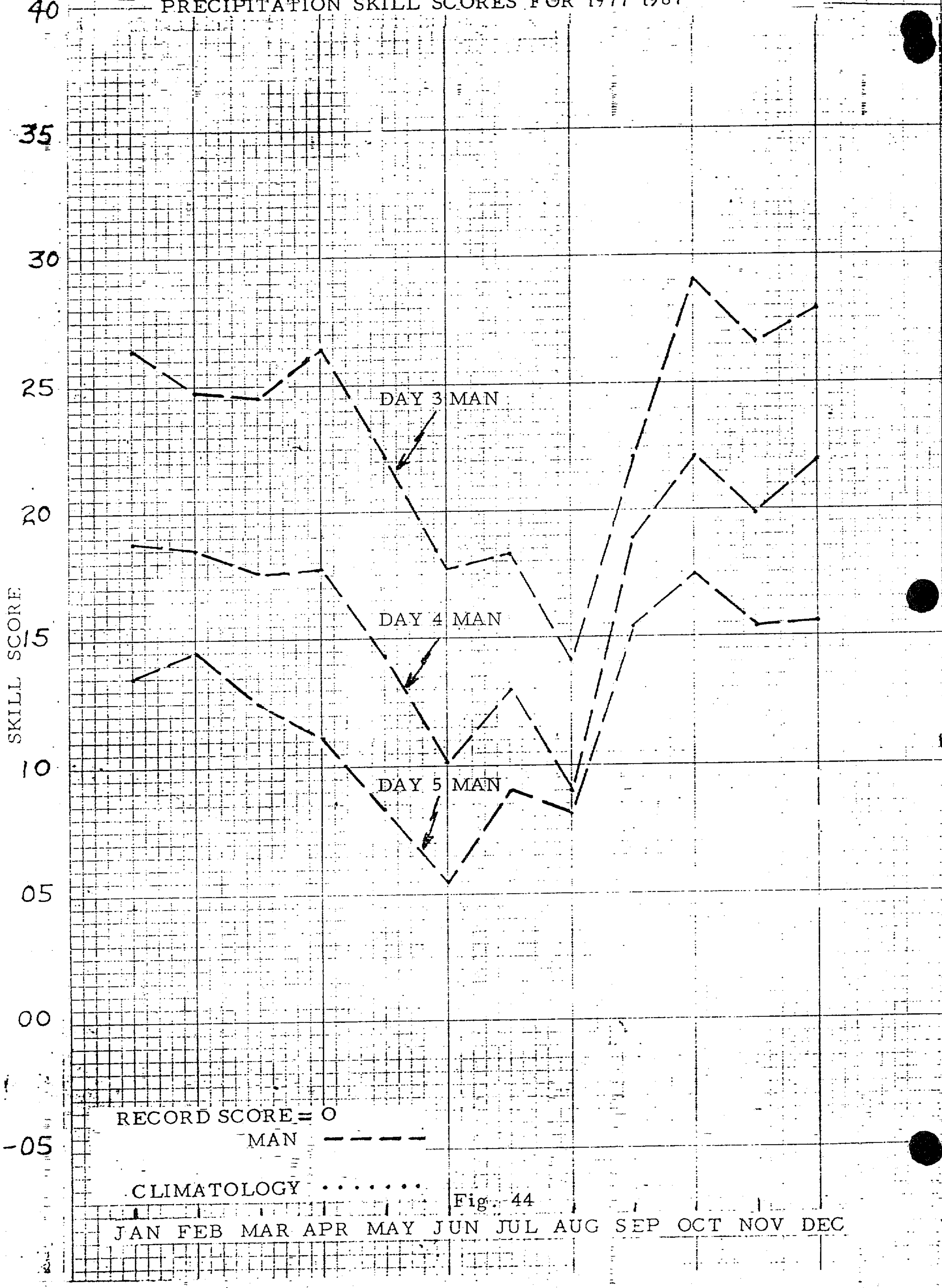


Fig. 44

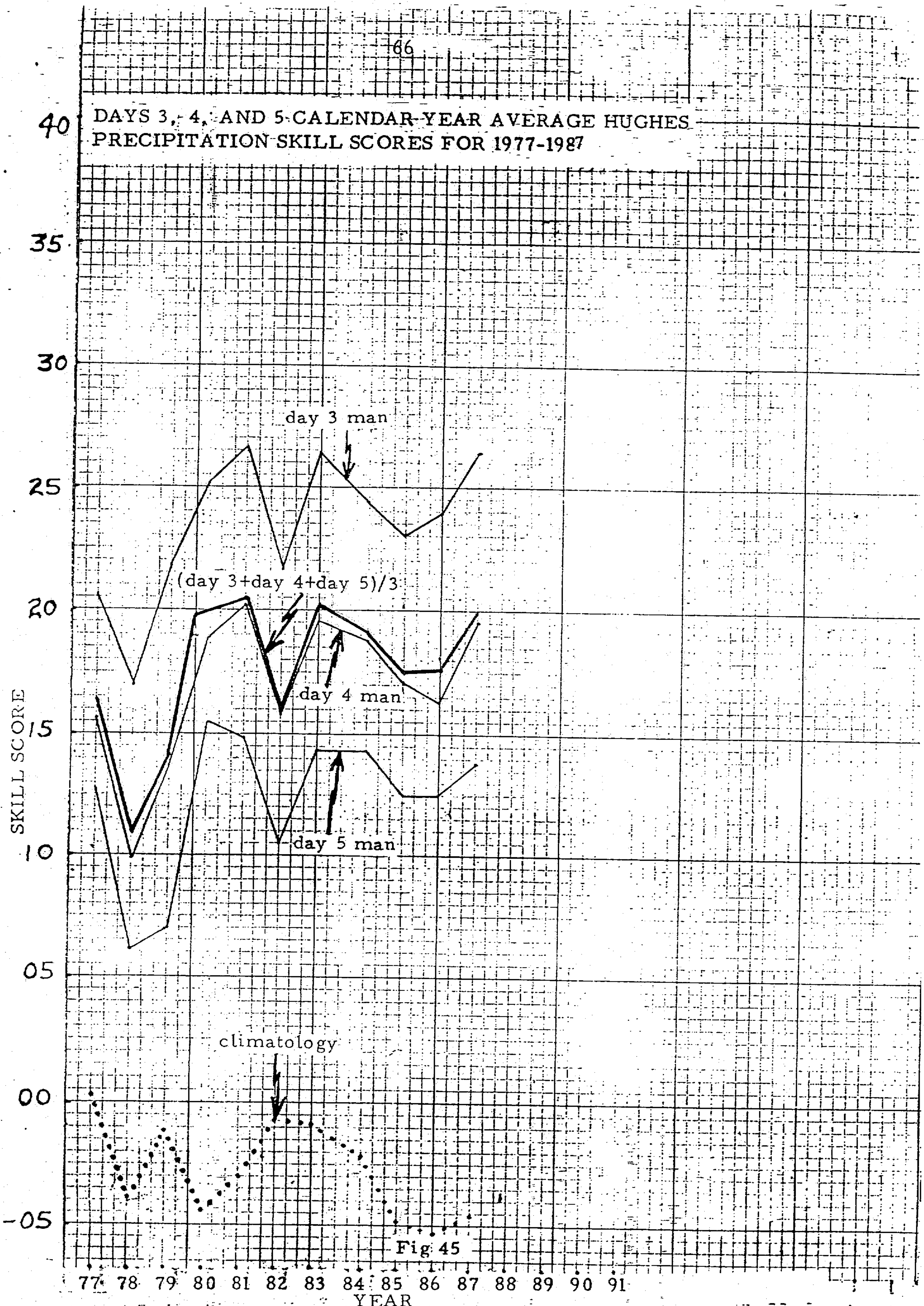

DAYS 3, 4, AND 5 CALENDAR-YEAR AVERAGE HUGHES PRECIPITATION SKILL SCORES FOR 1977-1987
40
35
30
25
20
15
10
05
00
-05
SKILL SCORE
day 3 man
(day 3+day 4+day 5)/3
day 4 man
day 5 man
climatology
77 78 79 80 81 82 83 84 85 86 87 88 89 90 91
YEAR

Fig 45

DAYS 3, 4, AND 5 MONTHLY MEAN HUGHES PRECIPITATION PROBABILITY SKILL SCORE FOR 1987

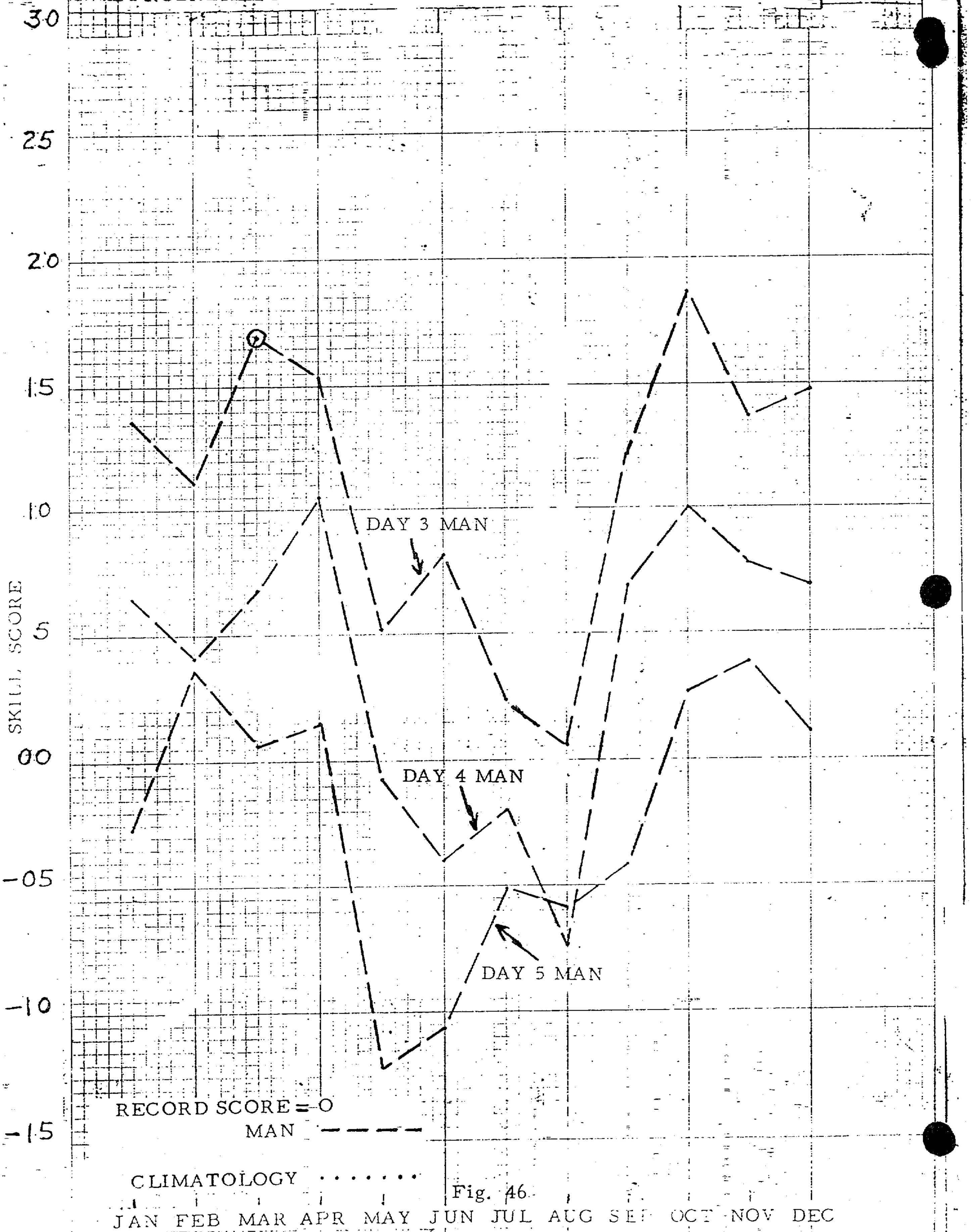


Fig. 46

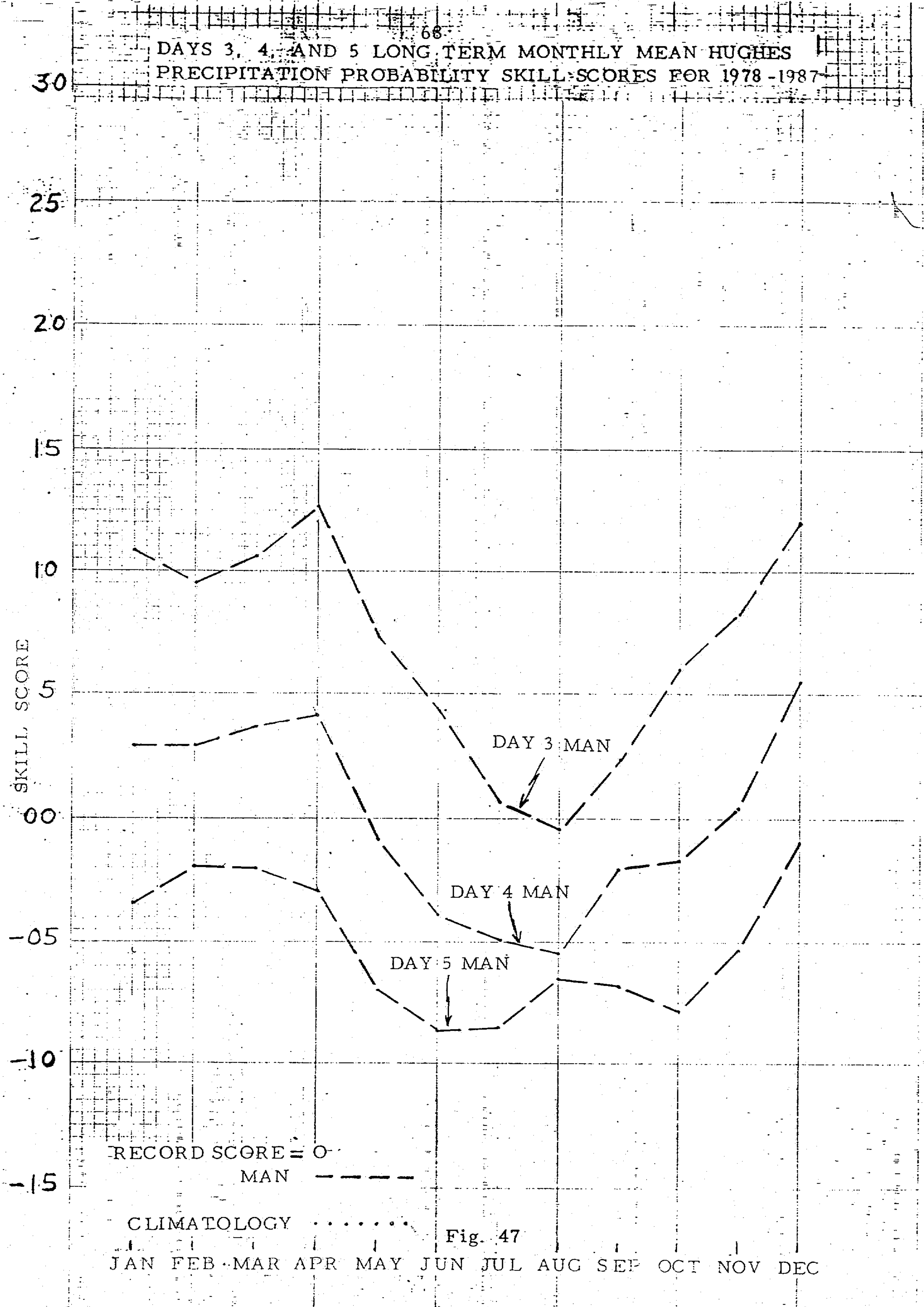

DAYS 3, 4, AND 5 LONG TERM MONTHLY MEAN HUGHES
PRECIPITATION PROBABILITY SKILL SCORES FOR 1978 - 1987
30
25
20
15
10
5
00
-05
-10
-15
SKILL SCORE
DAY 3 MAN
DAY 4 MAN
DAY 5 MAN
RECORD SCORE = O
MAN
CLIMATOLOGY
JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC

Fig. 47

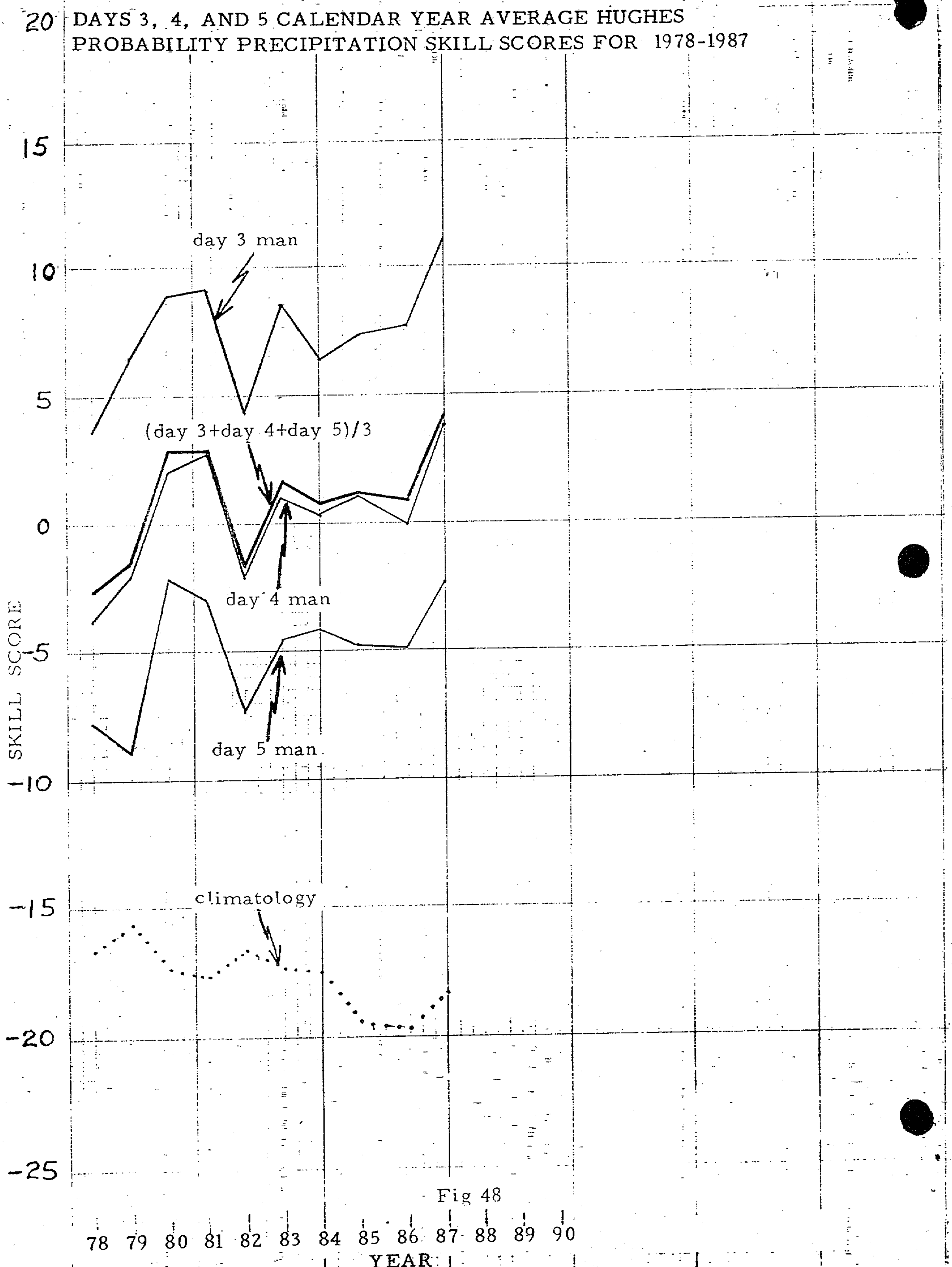

DAYS 3, 4, AND 5 CALENDAR YEAR AVERAGE HUGHES PROBABILITY PRECIPITATION SKILL SCORES FOR 1978-1987
20
15
10
5
0
-5
-10
-15
-20
-25
SKILL SCORE
day 3 man
(day 3+day 4+day 5)/3
day 4 man
day 5 man
climatology
78
79
80
81
82
83
84
85
86
87
88
89
90
YEAR

Fig 48

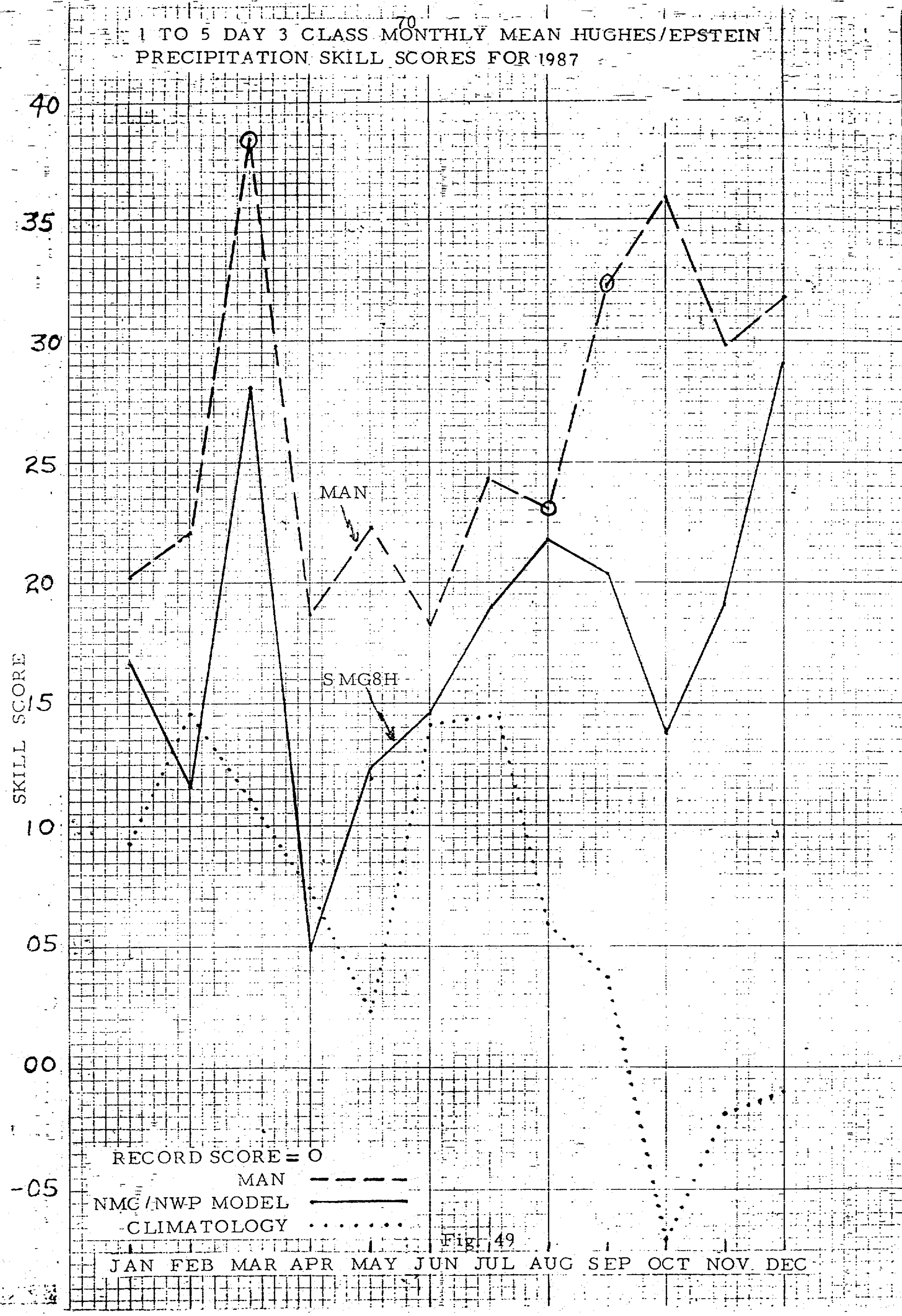

1 TO 5 DAY 3 CLASS MONTHLY MEAN HUGHES/EPSTEIN
PRECIPITATION SKILL SCORES FOR 1987
SKILL SCORE
40
35
30
25
20
15
10
05
00
-05
MAN
SMG8H
RECORD SCORE = O
MAN
NMC/NWP MODEL
CLIMATOLOGY
JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC

Fig. 49

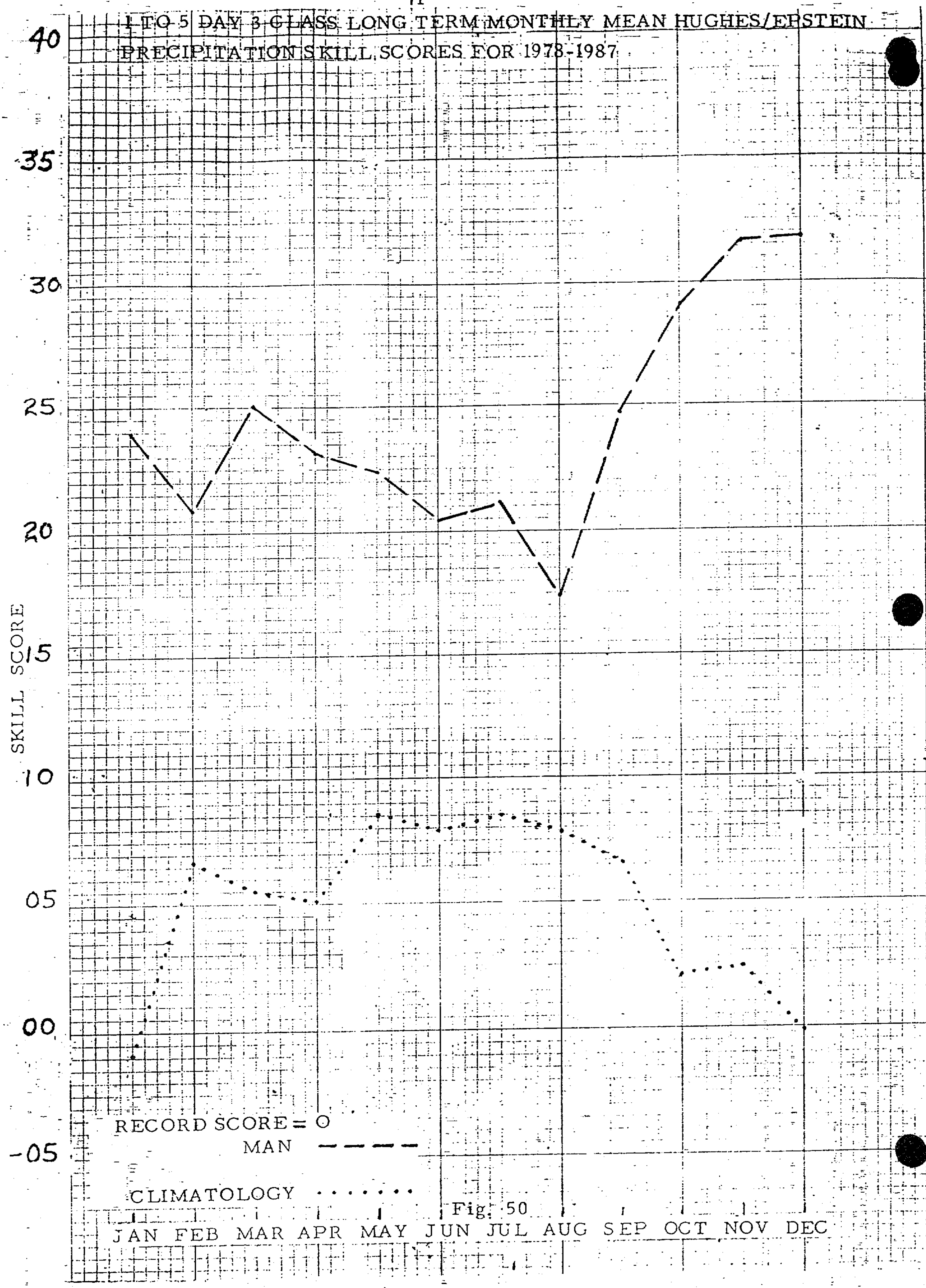
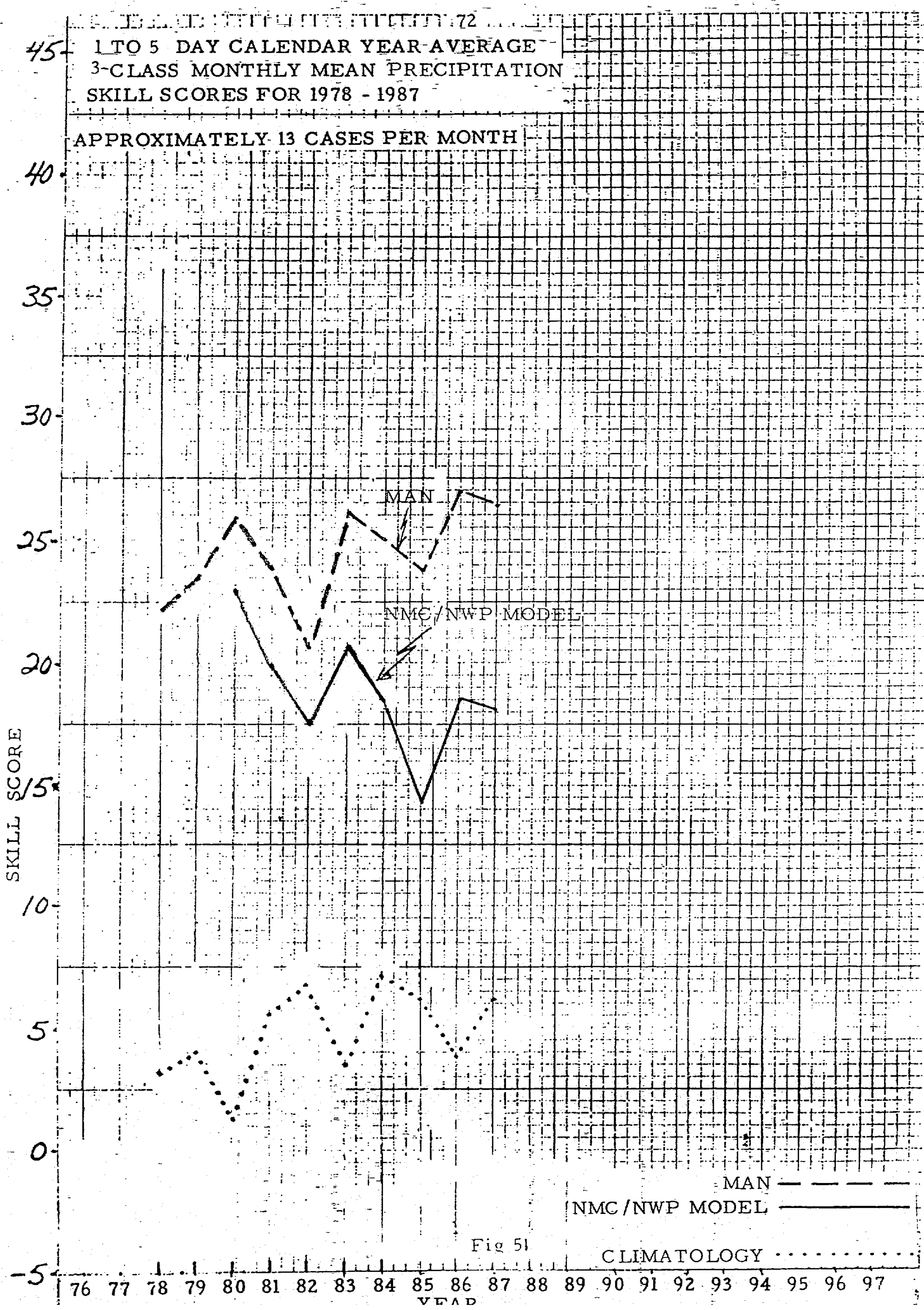

1 TO 5 DAY 3 CLASS LONG TERM MONTHLY MEAN HUGHES/EPSTEIN
PRECIPITATION SKILL SCORES FOR 1978-1987
SKILL SCORE
40
35
30
25
20
15
10
05
00
-05
RECORD SCORE = O
MAN
CLIMATOLOGY
JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC

Fig. 50



72
1 TO 5 DAY CALENDAR YEAR AVERAGE
3-CLASS MONTHLY MEAN PRECIPITATION
SKILL SCORES FOR 1978 - 1987
APPROXIMATELY 13 CASES PER MONTH
45
40
35
30
25
20
15
10
5
0
-5
SKILL SCORE
MAN
NMC/NWP MODEL
MAN
NMC/NWP MODEL
CLIMATOLOGY
76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97
YEAR

Fig 51

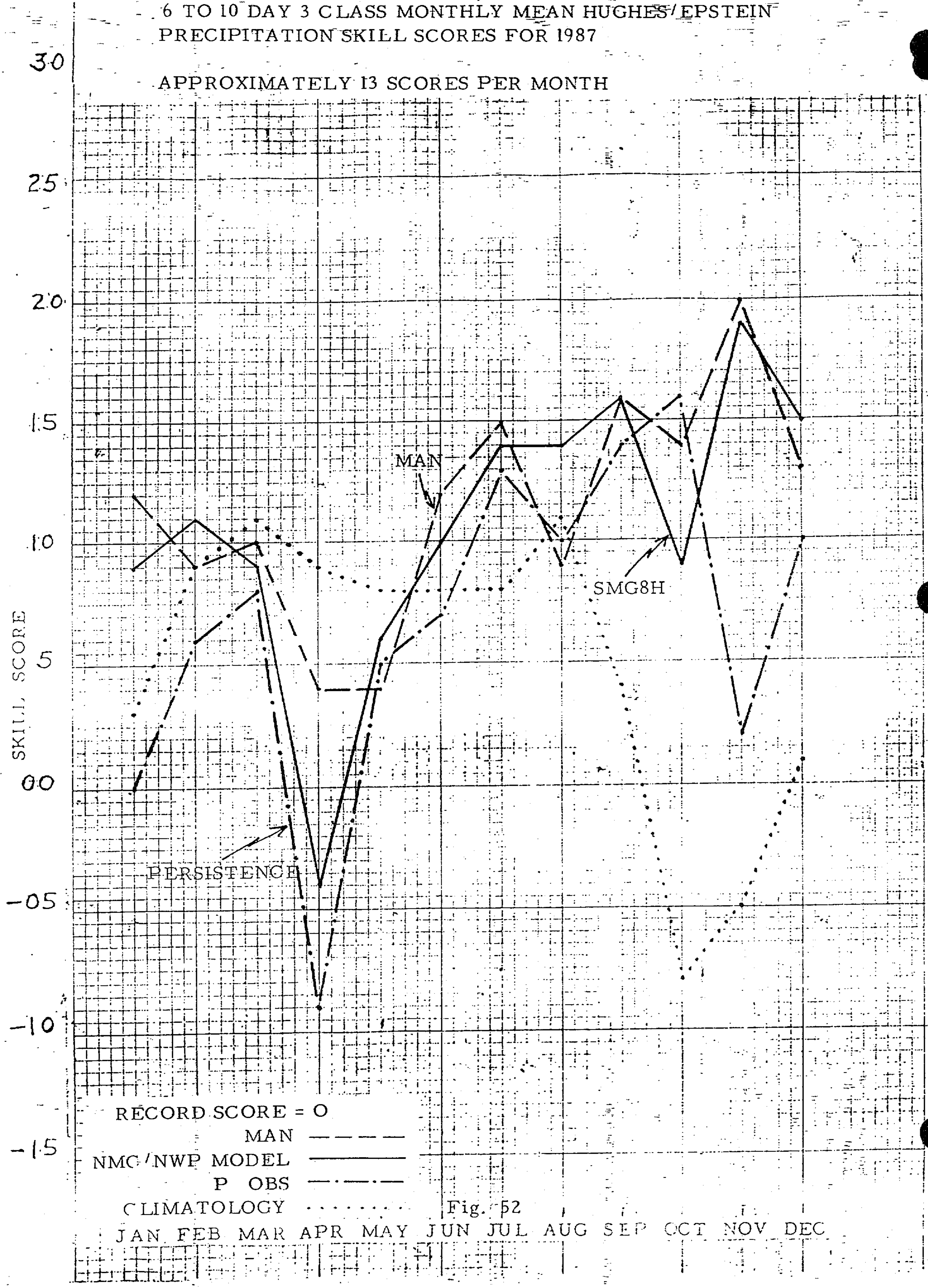

6 TO 10 DAY 3 CLASS MONTHLY MEAN HUGHES/EPSTEIN PRECIPITATION SKILL SCORES FOR 1987
APPROXIMATELY 13 SCORES PER MONTH
3.0
2.5
2.0
1.5
1.0
5
0.0
-05
-10
-15
SKILL SCORE
MAN
SMG8H
PERSISTENCE
RECORD SCORE = O
MAN
NMC/NWP MODEL
P OBS
CLIMATOLOGY
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC

Fig. 52

6 TO 10 DAY 3 CLASS LONG TERM MONTHLY-MEAN HUGHES/EPSTEIN PRECIPITATION SKILL SCORES FOR 1978-1987

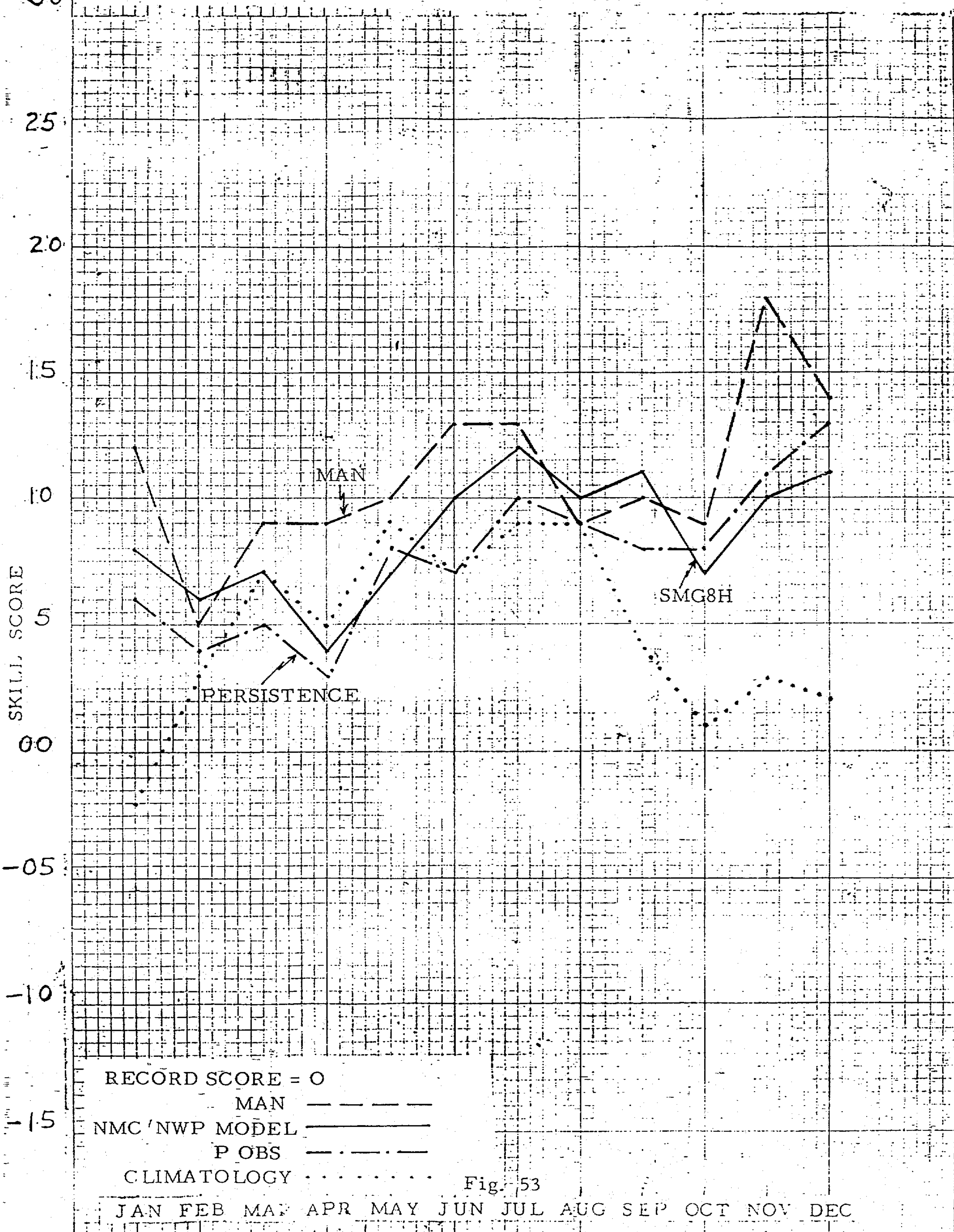


Fig. 53

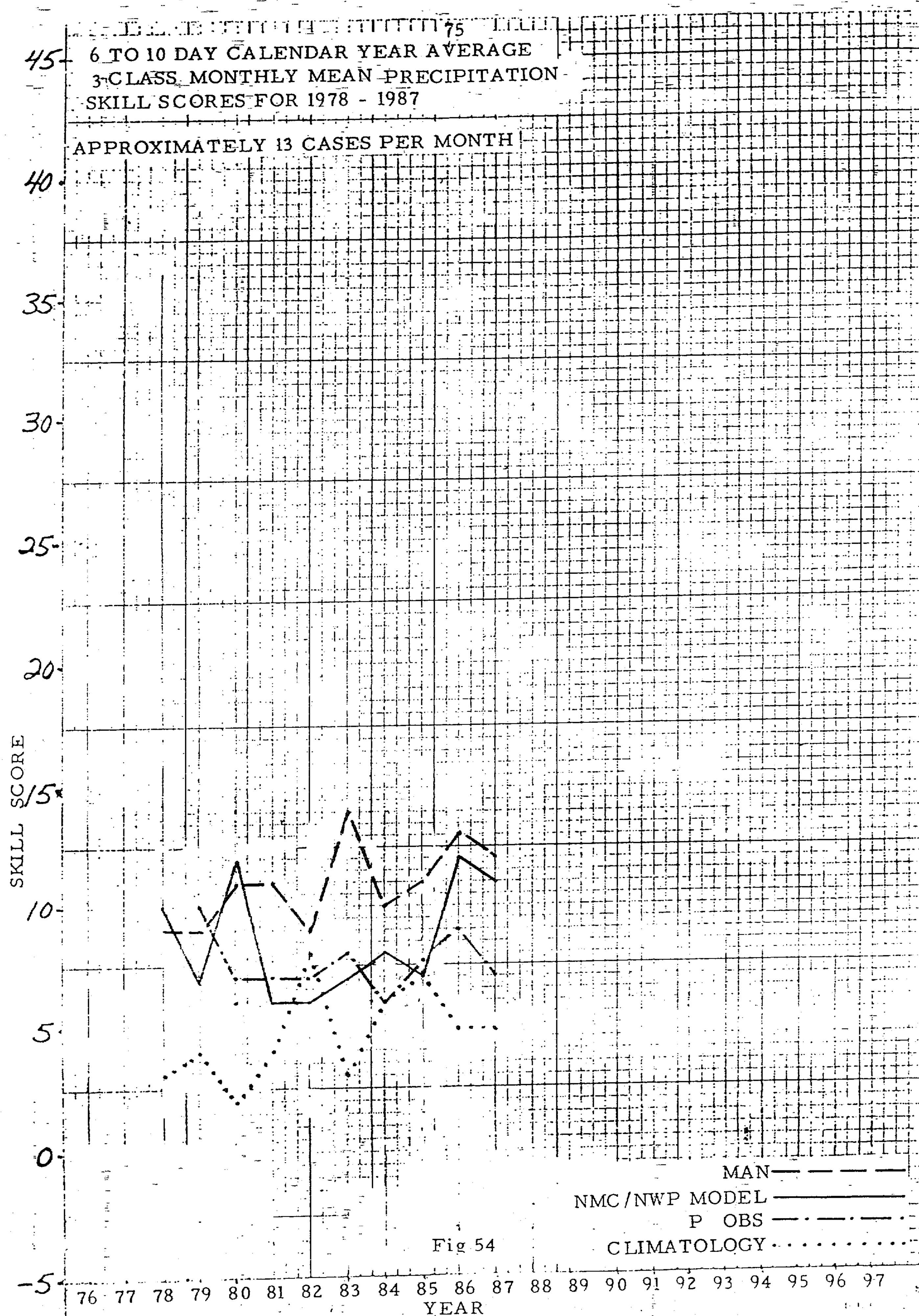

6 TO 10 DAY CALENDAR YEAR AVERAGE
3-CLASS MONTHLY MEAN PRECIPITATION
SKILL SCORES FOR 1978 - 1987
APPROXIMATELY 13 CASES PER MONTH
SKILL SCORE
45
40
35
30
25
20
15
10
5
0
-5
76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97
YEAR
MAN
NMC/NWP MODEL
P OBS
CLIMATOLOGY

Fig 54

SECTION 4

Man & Machine (NMC/NWP Guidance)

Days 1 through 9 Monthly Mean Sea Level Pressure & 500 MB

Scores

DAYS 1 THROUGH 9 NORTH AMERICAN AREA MSLP AND 500MB STANDARDIZED CORRELATION SCORES FOR DEC 86 JAN FEB 87

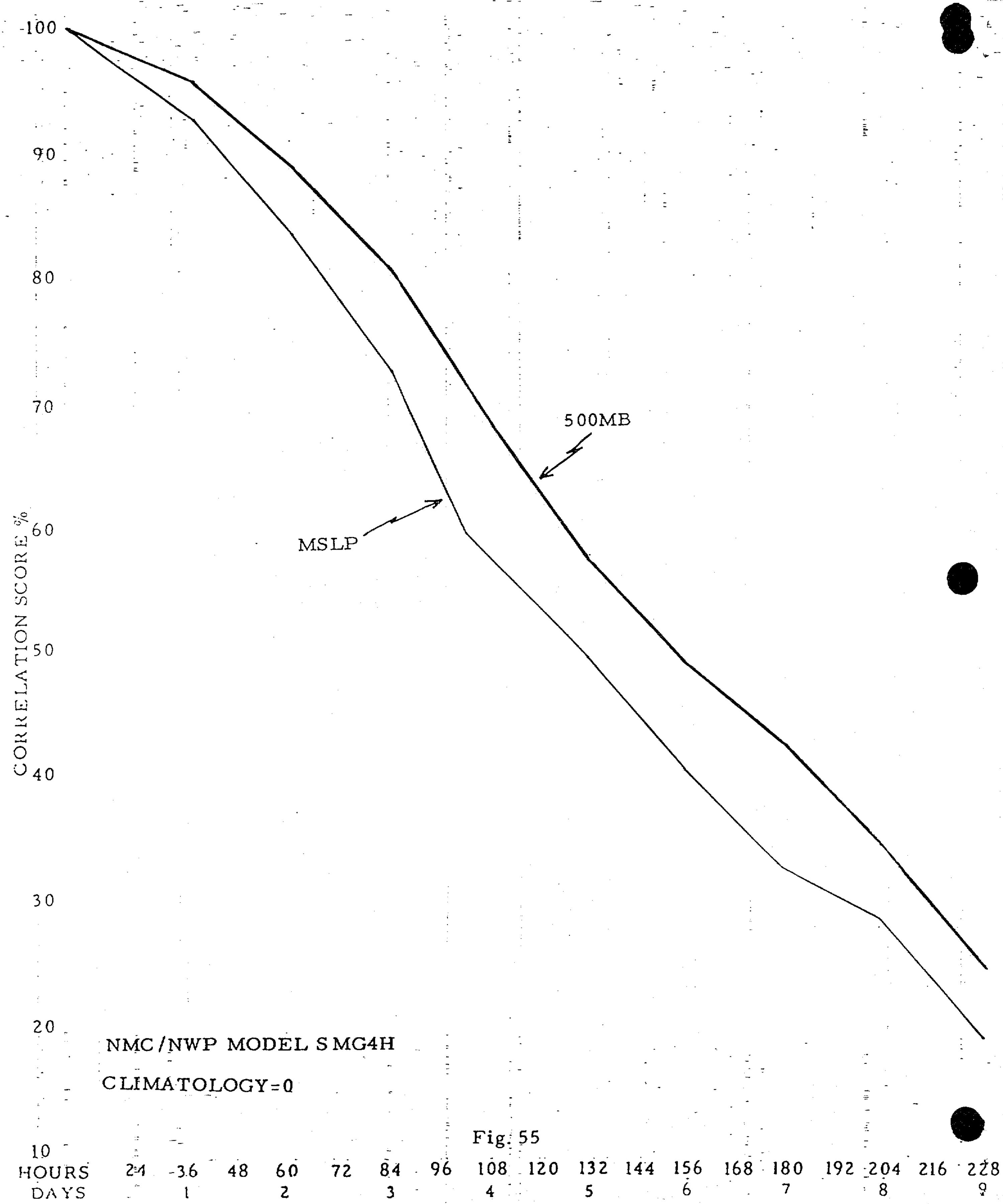


Fig. 55

DAYS 1 THROUGH 9 NORTH AMERICAN AREA MSLP AND 500MB STANDARDIZED CORRELATION SCORES FOR MAR APR MAY 87

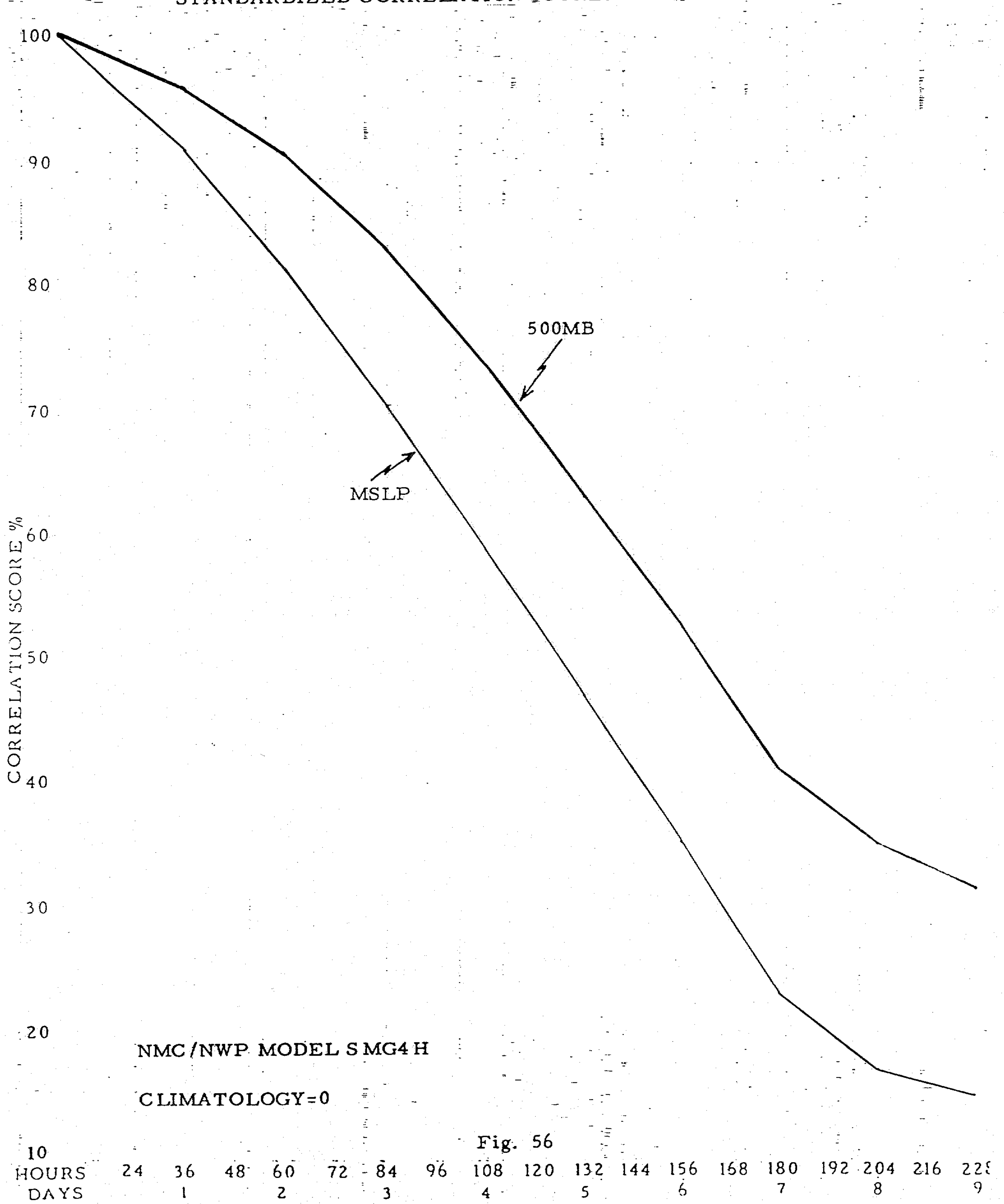


Fig. 56

DAYS 1 THROUGH 9 NORTH AMERICAN AREA-MSLP
STANDARDIZED CORRELATION SCORES FOR JUN JUL AUG 87

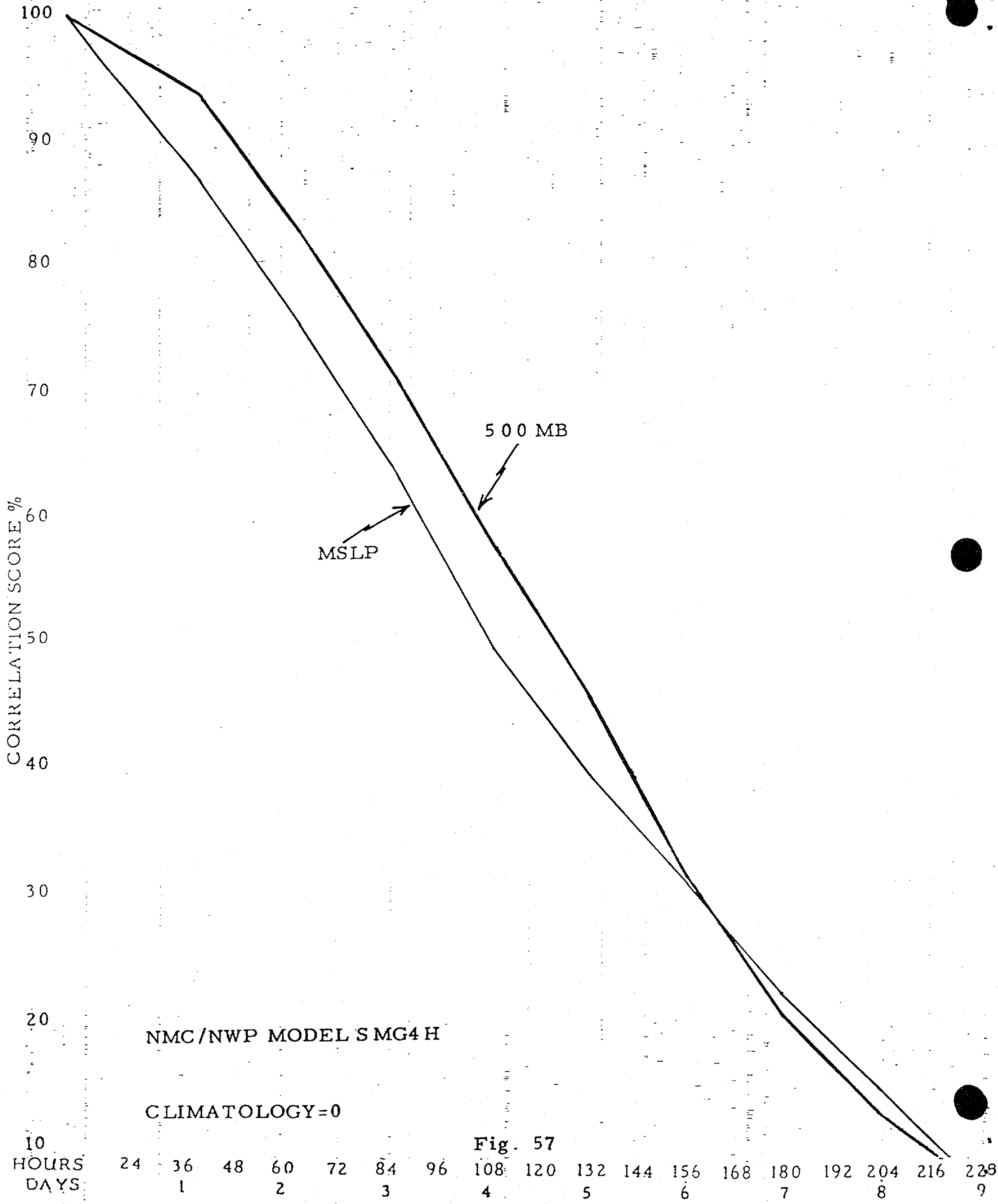


Fig. 57

DAYS 1 THROUGH 9 NORTH AMERICAN AREA MSLP AND 500MB STANDARDIZED CORRELATION SCORES FOR SEP OCT NOV 87

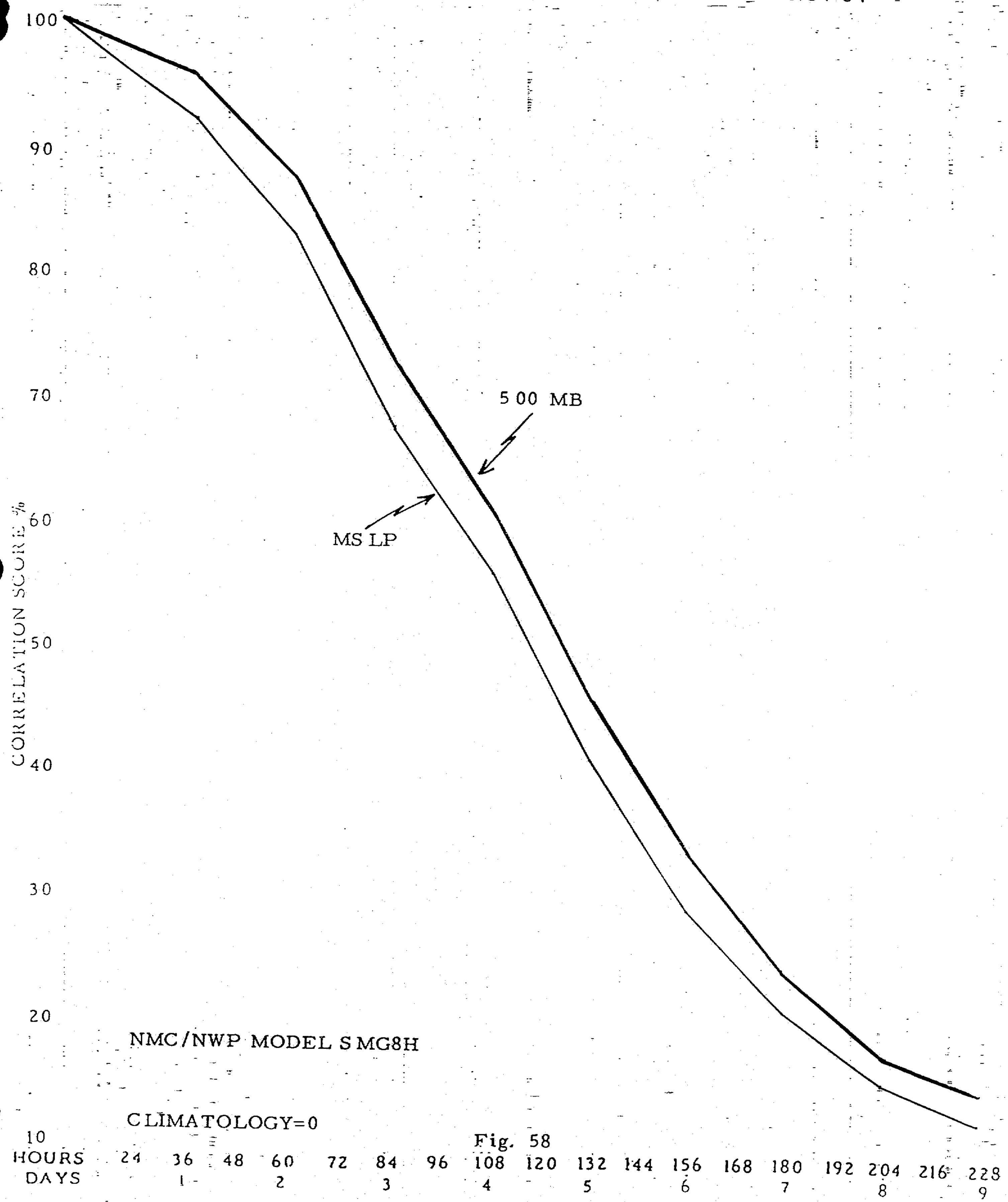


Fig. 58

COMMENTS

SECTION 1 - MSLP & 500 MB CORRELATION SCORES PAGES 12 TO 34

The pattern correlation score (Appendix A) has been the basic score used by the MRFG to verify the MSLP and 500 mb progs since the start of the MRFG program. The correlation score was chosen because it is more sensitive to the phasing of troughs and ridges (considered to be more important) than to the depth or heighth of these systems. The MSLP and 500 mb operational analyses (HUF) were used to verfy the forecast through 1976 and the LFM since 1977.

The North America (NA) standardized correlation score is the oldest score of record. The US subset unfortunately was contaminated from the beginning through 1975 by a coding (program) error affecting the observed field (verifying analysis).

It was assumed from the start that a MSLP standardized (anomalous field) score of greater than 0.0 (climatology) would result in the derived forecasts of temperature and precipitation having more skill than climatology (as a forecast). However, experience has indicaed that a NA score of 0.17 or better is required to accomplish this.

Most of the forecasters complained from the beginning about verifying a forecast of the anomalous MSLP field (which they could not "see") instead of the one they produced (the actual field). In order to appease the forecaster and obtain a score for the normal (climatology) as a forecast the unstandardized (actual MSLP field) score was introduced in 1977 and has been used successfully ever since.

A glance at figures 2 though 22 shows that, for the most part, the monthly mean scores during 1987 were higher (better) than the long term mean scores (note - the long term mean includes the 1987 scores). Also a comparison of the current long term mean scores (figures 3,6,9,12,15,18, and 21) with those published in NMC ON 326 of February 1987 indicates an upward trend. The many monthly mean record scores (figures 2,5,8,11,14,17, and 20) set by both the man and NMC/NWP model guidance resulted in 1987 being basically a record year (figures 4,7,10,13,16,19, and 22).

No comment is made concerning the "betterment" of the man over the NMC/NWP model guidance except that it appears to be significant. Since the scores for the circulation were near records, one might expect the derived forecasts of temperatures and precipitation also to be near record levels.

SECTION 2 - TEMPERATURE ABSOLUTE ERROR & SKILL SCORES PAGES 35 TO 57

In 1987, as usual, the bi-monthly mean absolute error minimum (figure 24 (a,b,c)) and maximum (figure 27 (a,b,c)) temperature scores for the man exhibited a clear superiority over the KL and climatology temperature forecasts for days 3, 4, and 5. The man minimum (figure 26) temperature scores tied all time records for days 3, 4, and 5 while the maximum (figure 29) tied all time records for days 3 and 5 and was second best for day 4.

In 1987, the man 6 to 10 day 5-class (figure 33) temperature skill score tied second best while the 3-class (figure 36) was second best.

SECTION 3 - PRECIPITATION SKILL SCORES PAGES 58 TO 75

The Gilman skill score, except for the problem mentioned in Appendix C, is quite sensitive to correct forecasts of precipitation. The Hughes skill score is quite sensitive to correct forecasts of no precipitation at stations with a high climatic precipitation probability. The experimental score is quite sensitive to correct forecasts of precipitation at stations with a low climatic precipitation probability. Thus, these three scores compliment one another.

In the 1987, as in recent years, the monthly mean Gilman (figure 39), Hughes (figure 43) and Hughes Probability (figure 46) precipitation skill scores for the man showed a clear superiority over climatology and the NMC/NWP model on days 3, 4, and 5. The man Gilman precipitation skill scores (figure 41) were record scores for days 3, 4, and 5. The Hughes skill (figure 45) and probability (figure 48) scores were at or near record levels and improved over 1986. The monthly mean 3-class precipitation skill scores for the man 1 to 5 day (figure 51) and 6 to 10 day (figure 54) forecasts were second and third best respectively in 1987.

SECTION 4 - MSLP, 500 MB & TEMPERATURES SCORES FOR DAYS 1 THROUGH 7 PAGES 76 TO 80

Certainly consideration has to be given, after looking at figures 55 through 58, to producing (operationally) for public consumption man MSLP (precipitation) and temperature forecasts for days 6 and 7.

CONCLUSION

1987, turned out to be a record year with regard to MSLP and precipitation forecasts, but, otherwise was more of a "high plateau" year for the MRFG. 1988 promises to be an interesting year with several changes expected to be introduced into the NMC/NWP MR model.

Appendix A

The standardized mean sea level pressure correlation score is used to determine the skill of the man and machine days 3, 4 and 5 mean sea level pressure forecasts. The correlation score is employed because the phasing instead of the intensity of systems primarily determines how well the various weather parameters can be forecast. The standardizing procedure prevents the contribution of the high variability (higher latitude) grid points from overwhelming the low variability grid points (lower latitude).

f = forecast mean sea level pressure at a grid point

o = observed mean sea level pressure at a grid point

σ = standard deviation at a grid point

n = normal mean sea level pressure at a grid point

$$F = \frac{f-n}{\sigma} \qquad 0 = \frac{o-n}{\sigma}$$

$\overline{F}$ = average standardized forecast across n grid points

$\overline{0}$ = average standardized observed across n grid points

$$\text{RMS } F = \sqrt{\overline{F^2}} \qquad \text{RMS } 0 = \sqrt{\overline{0^2}}$$

$$\text{RMS Error} = \sqrt{\overline{(F-0)^2}}$$

$$\text{Average Absolute Error} = \overline{|F-0|}$$

$$\text{Correlation} = \frac{\overline{F0} - \overline{F}\,\overline{0}}{\sqrt{(\overline{F^2} - \overline{F}^2)(\overline{0^2} - \overline{0}^2)}} \quad X100$$

Since the normal mean sea level pressure is subtracted from the forecast/observed pressure at each grid point, it is assumed that the correlation of the normal to the observed is always zero. Therefore, any positive score is considered to have skill over the normal. Some doubts have been raised about this assumption, however, and for the past 5 years the unstandardized correlation score also has been calculated. This procedure allows a correlation score to be computed for the normal. This score then is simply the correlation of the forecast to the observed mean sea-level pressure.

APPENDIX B

The 5 day mean temperature skill score is a generalization of the Heidke skill score where the expected values are derived from the observed temperature

$$\text{Heidke Skill} = \frac{C-E}{N-E}$$

C = total correct (hits)
N = total number of forecasts (61)
E = expected number of hits

The expected value is calculated as follows from the number of stations in each of the observed temperature categories:

E = 1/8 x Much Below + 1/8 x Much Above +
1/4 x Below + 1/4 x Above + 1/4 x Normal

The 5-day mean 3-class temperature skill score simply "lumps" together the much below with the below and the much above with the above. The expected (E) then is equal to 1/4 X Below + 1/4 X Normal + 1/4 Above.

Appendix C

The Gilman skill score is a generalization of the Heidke skill score where the expected values are derived from a randomized version of the precipitation forecast.

Heidke Skill = $\frac{C-E}{N-E}$

C = total correct (hits)

N = total number of forecasts (100)

E = expected number of hits

However, for a randomized forecast allowance must be made for stations having far different precipitation climate (N POP) across the United States. Therefore, to compute and score an expected chance forecast, climatology must be considered. The procedure for this is as follows:

First, the actual number of forecasts of precipitation are distributed randomly taking into account station climatology. The expected number of chance hits is then given by:

$$E = \sum^{N} (p_i r_i + (1 - p_i)(1 - r_i)) \text{ or}$$

$$E = 2\sum^{N} p_i r_i + N - \sum^{N} p_i - \sum^{N} r_i \quad (a)$$

where $r_i = 1$ for precipitation ($\geq .01$ inch) and 0 for no precipitaiton ($< .01$ inch). Now an expression for p_i, which is the probability that after the forecast precipitation events are redistributed randomly a forecast precipitation event will fall at point "i" is given approximately by $p_i \approx F\frac{a_i}{\sum^{N} a_i}$ (b). Here F = total number of forecasted precipitation events and a_i = climatic precipitation probability (N POP). This approximate value for p_i is most valid for small values of F and ($a_i / \sum a_i$) and is unstable at times. Because of this instability the less sophisticated but more stable Hughes skill score was developed.

Substituting the expression (b) into (a) gives $E = \frac{2F\sum^{N} a_i r_i}{\sum^{N} a_i} + N - F - R$, where E = the approximate expected value of a randomized forecast, R = total precipitation cases, and N = total number of stations. If the climatic probabilities are uniform ($a_i = a_j = a$), then the approximate value of E reduces to the standard Heidke value given by: $E = \frac{(N-F)(N-R)+FR}{N}$.

Appendix D

The Hughes skill score is a generalization of the Heidke skill score where the expected values are derived from the observed precipitation:

$$\text{Heidke Skill} = \frac{C-E}{N-E}$$

C = total correct (hits)
N = total number of forecasts (100)
E = expected number of hits

If the average precipitation climate (NPOP) of 12 stations having precipitation is 25, then the expected (precipitation) is simply 12 x .25 or 3 stations. If the average NPOP of the (100-12) stations not having precipitation is also 25 then the expected (no precipitation) is simply 88 x (1.0-.25) or 66 stations. The total expected (E) then is 69 stations. If the forecaster hit (C) 75 stations correctly, his skill score then is (75-69)/(100-69) x 100 or 19.

APPENDIX E

The (Hughes) probability score is not a skill score yet it is quite simple to understand. A rough score (RS) is calculated for each station (N=1 to 100) as follows:

Forecast	Observed	RS
(DN POP + NPOP) ≥30	P=1	+(1 - NPOP)
(DN POP + NPOP) ≥30	P=0 and NPOP ≥50	-(NPOP)
(DN POP + NPOP) <30	P=1 and NPOP ≥50	-(NPOP)
(DN POP + NPOP) ≥30	P=0 and NPOP <50	-(1 - NPOP)
(DN POP + NPOP) <30	P=1 and NPOP <50	-(1 - NPOP)
(DN POP + NPOP) <30	P=0	+(NPOP)

Since the total rough score (TRS) for the 100 stations does not equal 100 points, a simple iterative technique is employed which uses the RS as a f(NPOP) for each station to bring the total number of points up to 100. The FORTRAN language routine is:

```
          TTY = 0
70        DO 69   I = 1, 100
          TRS = (100.0 - TRS) * ABS(RS(I)) * .01
          IF(RS(I)) 73, 74, 74
73        RS(I) = RS(I) - TRS
          GO TO 69
74        RS(I) = RS(I) + TRS
69        TTY = TTY + ABS(RS(I))
          TRS = TTY
          TTY = 0.0
          IF (TRS - 99.8) 70, 71, 71
71        CONTINUE
```

APPENDIX F

The 5-Day mean precipitation skill score is a generalization of the Heidke skill score where the expected values are derived from the observed precipitation:

$$\text{Heidke Skill} = \frac{C-E}{N-E}$$

C = total correct (hits)
N = total number of forecasts (100)
E = expected number of hits

For example, in January the number of stations in the area covered by the (NP/P), (NP/M/H) and (L/M/H) categories is 21, 28 and 51 respectively. The average value of the probability of NP for the stations in the (NP/P) area is 70% and 40% in the (NP/M/H) area. Now if (NP/L) is coded as 1, M as 2 and (P/H) as 3, then the number of stations expected to have coded value 1 thru 3 is as follows:

33% of (L/M/H) = 51 x .33 = 17 stations coded 1, 2, 3

40% of (NP/M/H) = 28 x .40 = 11 stations coded as 1 and 8.5 coded as 2,3

70% of (NP/P) = 21 x .70 = 14.7 stations coded as 1 and 6.3 coded as 3

Thus, code 1 = 17 + 11 + 14.7 = 42.7 stations
code 2 = 17 + 8.5 = 25.5 stations
code 3 = 17 + 8.5 + 6.3 = 31.8 stations
100.0 stations

Therefore, the expected value = .427a + .255b + .318c

where a, b and c are the number of coded values 1, 2 and 3 observed.